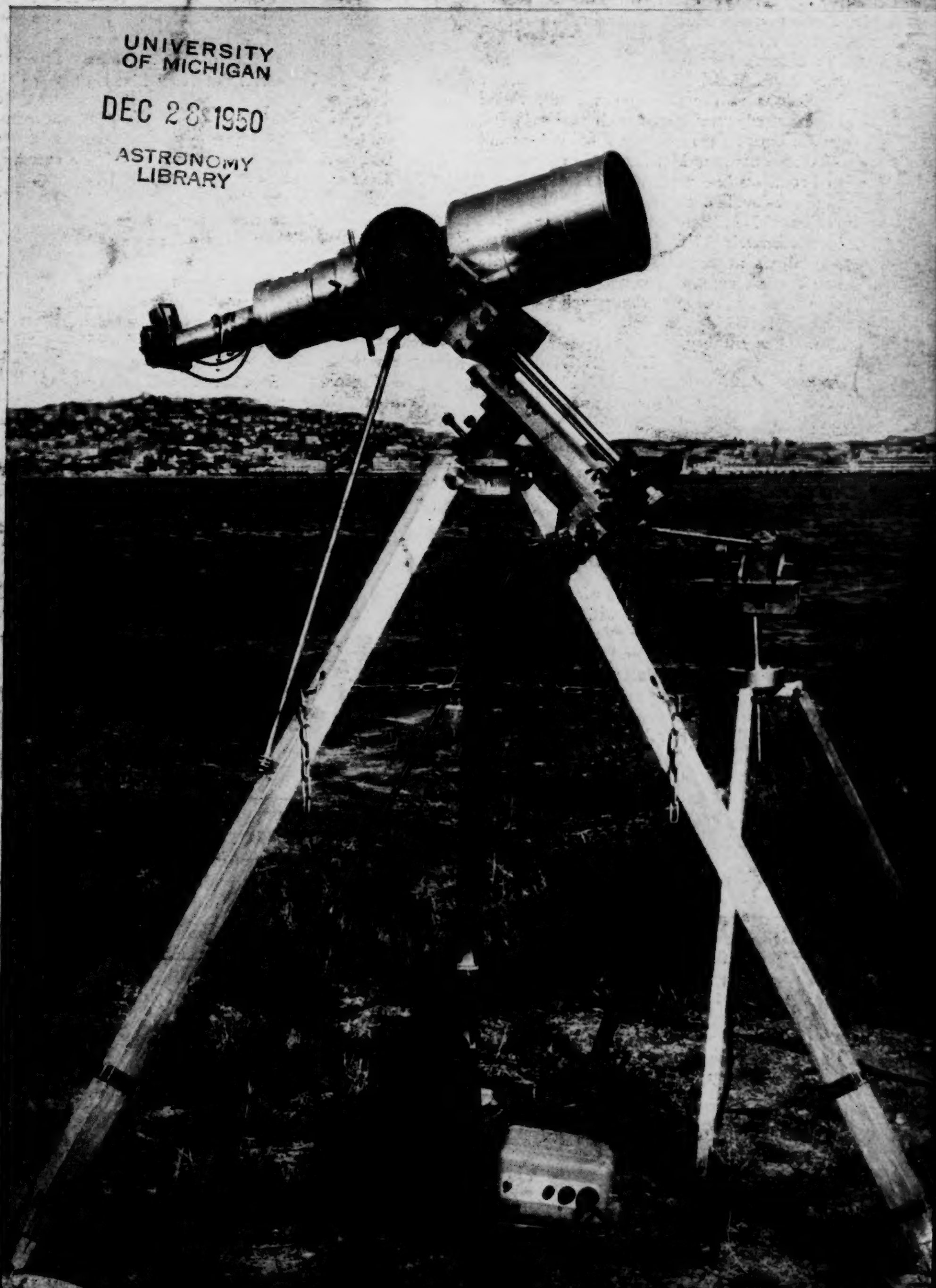
Sky and TELESCOPE



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Vol. X, No. 3
JANUARY, 1951
Whole Number 111

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Power-driven portable mounting

SKY and TELESCOPE

LETTERS

Sir:

Against the background of a sweeping panorama extending over San Francisco Bay and beyond the Berkeley Hills, Ray Strong, the western landscape artist of Mill Valley, Calif., now has completed two excellent paintings of the lunar eclipse occurring on the early evening of September 25, 1950. Selecting a site on the shore of Paradise Cove, close by the base of the mountain, Tamalpais, he had prepared in advance his outlines and sketches with projected positions of the moon during eclipse. Thereby, he was enabled effectively to concentrate on atmospheric shadings and color evaluations. One of his scenes portrays the moon eclipsed in early totality, quite low above the Berkeley Hills; the other presents a higher position approaching the end of totality.

As far as known to the writer, these are the first paintings of a lunar eclipse portrayed in landscape setting. Weather conditions at the time were ideal, visual effects finely variegated, rich and colorful. In timing and movement of color and shadow changes, Mr. Strong's recordings in broad outline were matched closely by the sea-level observations of Charlotte McDonald in San Francisco at a point approximately 14 miles to the south. On Tamalpais at the 2,600-foot level, a pale smoke-pink remained constant, with delicate infusions of light blue which appeared briefly following the onset and nearing the end of totality.

LEWIS LINDSAY
2217 Mission St.
San Francisco, Calif.

Sir:

C. C. Wylie has reduced metric measures of the Hoba West meteorite made by L. J. Spencer and concluded that it is a space box (rectangular parallelopiped) approximately 10 x 9 x 3 feet (**Sky and Telescope**, November, 1950, page 4). This conclusion is unjustified, for Spencer actually found the dimensions of Hoba West to be: length, 295 cm.; width, 284 cm.; ". . . with a thickness at one end of 122-111 cm. and at the other end of 75-55 cm." The bottom surface determined by these measures is certainly not parallel to the flat top of the meteorite, i. e., Hoba is not a space box. Furthermore, as Spencer has pointed out, ". . . it is not known whether the under surface is flat or not." If it is not, the problem of computing the volume of Hoba West, once its true shape is revealed, will require something more than a simple rule of thumb.

Wylie also concluded that ". . . since the shale is about 50 per cent metal . . .," Spencer's figure 88 ". . . is metric tons, and it is not an approximation to the mass at the time of striking, but an approximation to the present weight of the meteorite plus the metal in the surrounding shale." This conclusion, based on the assumption that half of the shale surrounding the meteorite is metal, is indefensible; for P. Range and R. Schreiter have shown (**Centr. f. Min.**, Abt. A, 1931, 390-398) that there is less than ¾ of one per cent of metal in the Hoba shale. Wylie's argument overshoots in the other direction if we assume that he really had in mind not metal in the shale, but that fraction of the shale which could be reduced back to metal in a hydrogen atmosphere, for as J. D. Buddhue has shown (**Contr. Meteoritical Soc., 4,** 199, 1949), this fraction exceeds 71 per cent, in the case of **surface** shale from Canyon Diablo. No doubt it is still larger for the compact, dense, subsurface Hoba West shale.

LINCOLN LaPAZ, director
Institute of Meteoritics
University of New Mexico

Reply by Dr. Wylie

Sir:

Dr. LaPaz has misinterpreted the intent of the formulas which I presented before Section D of the American Association for the Advancement of Science in December, 1949. They were not supposed to be of high accuracy, but simple rules of thumb for calculating with reasonable accuracy the weight of iron meteorites.

On the Hoba West meteorite, to which he refers, my rule of thumb gives a figure for the weight within about two per cent of that obtained by Spencer, a satisfactory agreement. The rule also shows that Spencer's statement, "adding 30 cm. all round, an original weight of 88 tons would be indicated," is erroneous or misleading. I suspected that instead of simply adding to the dimensions of the meteorite, he had added the shale and allowed for the difference in the specific gravity. Spencer gives for the specific gravity of the shale 4.021 which is 50.5 per cent, or practically one half, of the specific gravity of the meteorite itself. Using my formula, a figure agreeing within about one per cent of that of Spencer is obtained, assuming that he means metric tons. This close agreement indicates that Spencer's figure is not an error but was obtained as indicated.

C. C. WYLIE, director
Meteor Section
The Meteoritical Society

Sir:

Our knowledge of Babylonian astronomy is rather limited. The only text which can with certainty be dated as far back as the Hammurapi dynasty is represented by the Venus tablets of Ammisaduga, two other texts, Hilprecht's text HS 229, which is a mathematical exercise of

(Continued on page 57)

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COVER: A rigid portable power-driven mounting built by W. C. Cheney, of West Seattle, Wash. The telescope shown is made up of a 4-inch Eastman Aero Ektar objective, f/6, and a 1¼-inch eyepiece. Puget Sound and the city of Seattle are in the distance. (See page 70.)

BACK COVER: A full-scale reproduction of a typical chart for variable star observing, the "b" chart of the American Association of Variable Star Observers, for the star T Cephei. It was drawn by D. F. Brocchi, based on the "Bonner Durchmusterung." Compare the scale and limiting magnitude with the "d" chart (for larger instruments and more detail) shown on page 73. Blueprints of such charts as these are used at the telescope to search for variables and estimate their magnitudes. (See page 72.)

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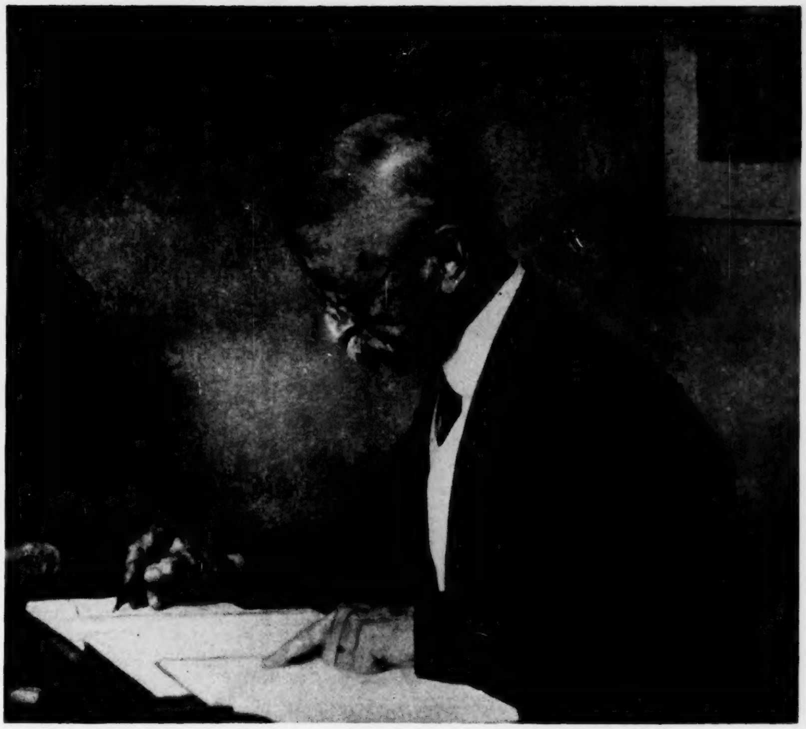


J. C. Kapteyn at his desk during the later years of his life.

J. C. Kapteyn Centennial

By P. J. van Rhijn, *Director*
Kapteyn Astronomical Laboratory, Groningen, Holland

On JANUARY 19th it will be 100 years since Jacobus Cornelius Kapteyn was born at Barneveld in the Netherlands. He was one of the leading astronomers during the first quarter of this century, and by his personal influence he induced astronomers all over the world to give their energies to the service of the ideal he had proposed.

The central problem at which he worked his whole life was that of the structure of the galactic system. He stated this problem more accurately than his predecessors had done; he collected observational data by means of which an approximate solution of the problem was given; and finally, he took a first step on the road leading to the mechanical explanation of the structure found.

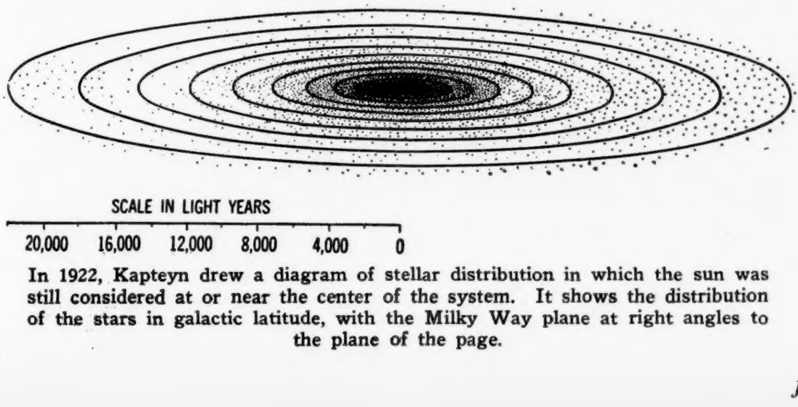
Let us examine more closely what exactly is the content of the problem. The galactic system consists of a great number of stars, matter between the stars, and clusters of stars. In Kapteyn's years little was known about interstellar matter and clusters, and Kapteyn therefore limited his investigation to the stars. Let us represent each of the stars by a little marble or globe, by means of which we may make a miniature copy of the stellar system. We arrange the globes in the space of one room, for instance, with the sun occupying the center of the room. We place each globe in a definite direction from the sun and at a distance representing to scale its actual distance from the sun. An examination of this miniature copy would at once acquaint us with the structure of the great system. By means of simple counts we should get to know the number of stars in each limited portion of the system, and the boundary to which the system extends in various directions could be read off directly from the reproduction.

Kapteyn's principal problem was: How to construct such a miniature universe? In the first of two attempts to solve it, he made the supposition that the motions of the stars show no preference for any special direction. He therefore assumed that as many globes in the miniature model moved upward as downward, as many to the left as to the right, as many forward as backward, and that the average velocity in every direction was the same. On working out the observational data it appeared, however, that this supposition was not fulfilled in the stellar system, so that the method had to be abandoned.

But the failure was really a success, for the proof that the motions of the stars are not at random led Kapteyn to the important discovery of the star streams. The globes in the model move preferably parallel to a definite direction; motions in other directions also occur, but less frequently.

After the road taken had thus turned out a blind alley, Kapteyn used a different approach to the central problem. If the directions and distances of all the stars in the system were known, the construction of the miniature universe would be a simple matter. This, however, was not the case at the time Kapteyn started his work (neither is it at present!). The observations of the directions of the stars gave little difficulty, but the distances were known only for a relatively small number of stars in the neighborhood of the sun.

It was therefore impossible to locate each individual globe in the miniature system. By statistical methods, however, Kapteyn derived the number of stars per unit volume in different parts of the system, though the position of each individual object was unknown. This method led to the end proposed and so gave a first approximation of the form of the system. Later Kapteyn, using the same method and aided by more complete data, for the second time gave an answer to the question. It appeared that the stars are distributed in a space having the form of a flat disk; the sun stood nearly in the center of the disk and the base was parallel to the Milky Way. The great number of stars that we see in the Milky Way is accounted for by the fact that the system extends farther in the direction of the Milky



In 1922, Kapteyn drew a diagram of stellar distribution in which the sun was still considered at or near the center of the system. It shows the distribution of the stars in galactic latitude, with the Milky Way plane at right angles to the plane of the page.

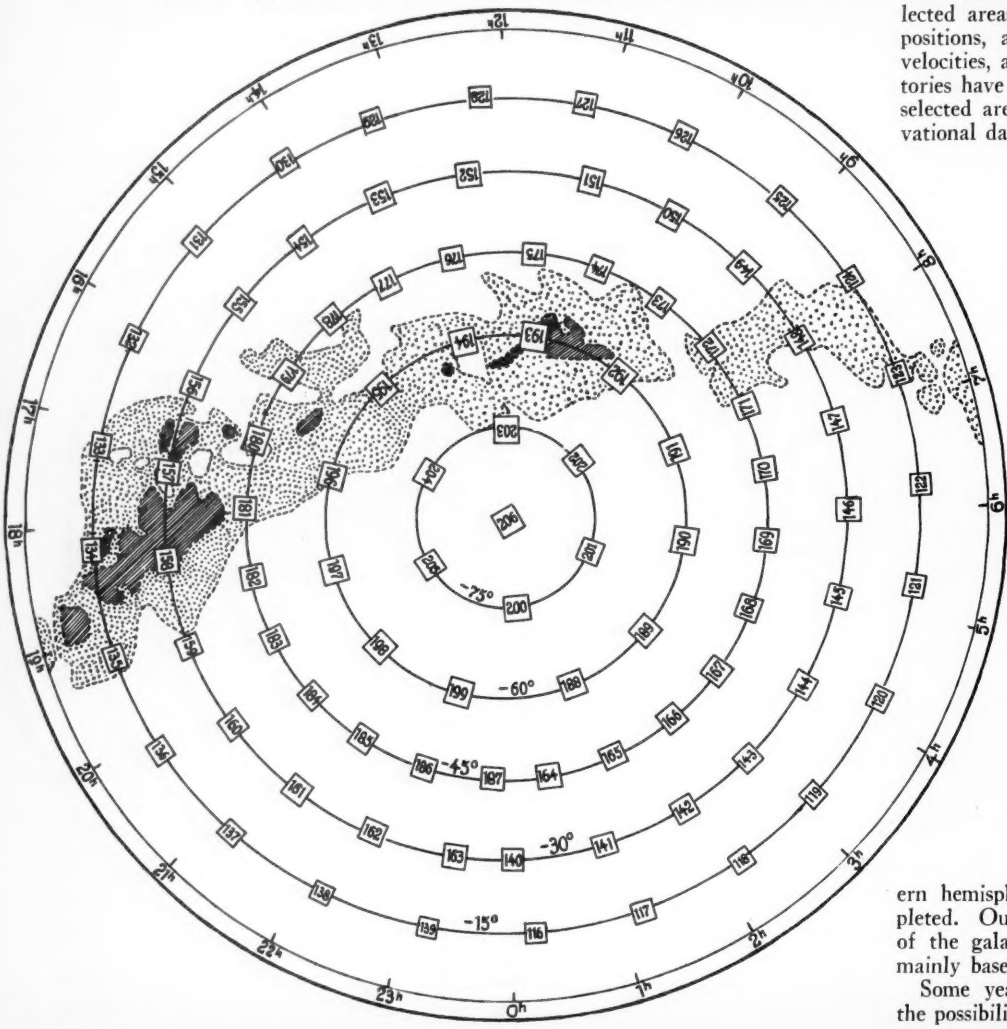
The Kapteyn Astronomical Laboratory at Groningen.

Way plane than in any other direction.

In the later years of his life, Kapteyn connected the two great investigations with which his name is associated. If the masses, the positions, and the velocities of all stars at a definite moment are given, the future form of the system can be deduced according to the laws of mechanics. This problem is far from being solved. Kapteyn made a beginning with the so-called dynamic conception of the system. He regarded the star streaming as a circular movement around a fixed center parallel to the plane of the Milky Way: Some stars move with the hands of a clock, others in the opposite direction. This movement should account for the flattened form of the system.

It is obvious that a great many data of observation are required for the solution of the problems discussed above. They are obtained chiefly by the photographic process. The astronomer at the telescope photographs specified areas of the sky; the plates are measured later in the laboratory. The astronomical laboratory at Groningen, founded by Kapteyn and bearing his name, was based on this procedure. But the work was too comprehensive for one institution and the number of faint stars was too great for them to be observed completely. Therefore, in 1906 Kapteyn proposed to the astronomers of his time to collect all data obtainable on the stars in 206 selected areas of the sky, including their positions, apparent brightnesses, colors, velocities, and so forth. Many observatories have been engaged in this plan of selected areas, and at present the observational data for the areas in the northern hemisphere have nearly been completed. Our knowledge of the structure of the galactic system near the sun is mainly based on these observations.

Some years before Kapteyn's death, the possibility of publishing his complete



The plan of Kapteyn's selected areas, as applied by F. Becker to the southern half of the sky. The Milky Way is outlined according to Pannekoek. The selected areas are four degrees square, spaced regularly along declination circles 15 degrees apart. Reproduced from a publication of the Potsdam Observatory.

works was considered by a committee of Dutch astronomers. When I wanted to fix up a plan with him, he said that we ought to wait until his investigations on the dynamics of the system could be included, "for," he continued, "if these are not correct, the rest is not worth reprinting either." We know now, some 30 years later, that his dynamical conception of the system was erroneous, but we do not agree that the rest is hardly worthwhile.

Various factors discovered after Kapteyn's death in 1922 have had a profound influence on our ideas, the main one being the absorption of light in interstellar space. Kapteyn was aware of the possibility that starlight might be absorbed, and of the influence this absorption might have on our concept of the stellar system. As early as 1909 he tried to find the amount of this absorption, and his method was practically the same as that applied some 30 years later by Stebbins and others. Whereas Stebbins succeeded, Kapteyn failed because the observational data available in 1909 were not of sufficient accuracy. Further, the star streams are not ascribed nowadays to a circular movement as Kapteyn did, but to a preference of the motions of the stars along the line toward the center of the system.

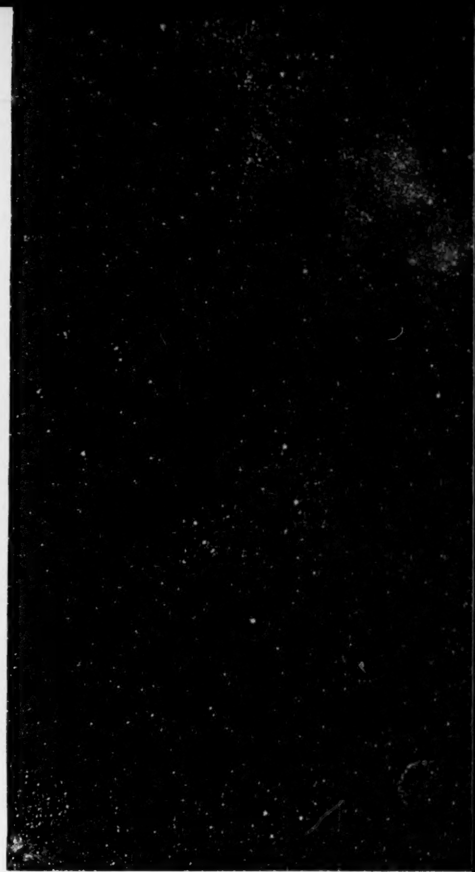
Kapteyn was a pioneer in his field of work. He was one of the first astronomers who stated the problem of the structure of the system clearly, developed the methods for its solution and made a first trial to solve the problem. Without his courage to attack the problem and to make a solution, which later required substantial corrections, we might not have known about the structure of the system what we know at present.

Kapteyn served the University of Groningen in the Netherlands for more than 40 years, and many Dutch astronomers have been his pupils. He did not demand much positive knowledge from his students, and the body of facts he dealt with in his lectures was small; he rather showed how the things that we now accept as settled were once scientific problems, and how former generations attacked and solved these questions. This was the secret of his fascinating lectures. One got the impression, not that the professor was narrating and the student listening, but that professor and student were collaborating in the solution of a scientific problem.

From 1908 to 1913, Kapteyn went each year to the Mount Wilson Observatory in California, where he was engaged in astronomical work connected with the program of the observatory. Many astronomers in the United States were his personal friends.

I had the privilege of collaborating with Kapteyn in the solution of the problems we have discussed here. What struck me repeatedly was the rare power he possessed of seeing in advance from which side a problem should be attacked to achieve a good result. As soon as he had stated the question, he began working at the solution and putting something on paper. As he himself said, "Let us start work, and the inspiration will come of itself," or at another time, "Probieren ist besser als studieren." If he happened to be on the wrong track he was astonishingly quick to perceive it, and he knew how to turn the unsuccessful attempt to advantage.

His friends loved Kapteyn for his simplicity and his cheerfulness. His heart was drawn toward the sunny side of everything he came in contact with, and he did not like to linger near the darker sides of reality, which a life as rich in deeds as his must have known in sufficient measure. Lastly, his personality was upheld by an undefinable confidence, and it was no accident that the last words Kapteyn wrote to me with reference to an astronomical undertaking were these: "Tout va pour le mieux."



In this region of Cygnus, covering about 220 square degrees, all or part of four of Kapteyn's selected areas are located, Nos. 40, 41, 65, and 66.

LETTERS

(Continued from page 54)

the prescientific stage of Babylonian astronomy, and the astrolabes, which represent the beginning of scientific astronomy, as they were the first attempt toward systematization of prescientific popular knowledge about stars appearing in the sky during different seasons of the year. The two tablets of mul Apin which appeared later made the system more complete.

Professor B. L. van der Waerden, Dutch mathematician who is studying some clay tablets 3,000 years old found in one, mul Apin, statements of the following kind concerning only the brightest stars:

"On the 15th of the month Duzu the star gag-si-sa rises; from the rising of gag-si-sa 55 days until the rising of nun-ki, and 60 days until the rising of sku-pa; from the rising of sku-pa it is 10 days until the rising of ab-shim," and so forth.

From other texts we know what most of these star names mean: gag-si-sa is Sirius, nun-ki is Canopus, sku-pa is Arcturus, and ab-shim is Spica. Now Professor van der Waerden wants to find out in what century these heliacal risings (first appearances in the morning sky before the sun) were observed. He has to make this computation for 1300 B.C., 1000 B.C., and 700 B.C., and then see which fits the whole pattern best.

For this computation he must know beforehand under what conditions a star near the horizon is visible or invisible, or more precisely how deep the sun must be below the horizon in order that a 1st- or 2nd- or 3rd-magnitude star may be seen rising or setting. Observations in Holland are not useful in this way because of the generally hazy, moist atmosphere. Babylonia had a dry climate with much more transparent sky. Therefore, Professor van der Waerden, through Dr. Bart J. Bok, of Harvard, called attention to the need for observations in the October, 1949, issue of **Sky and Telescope**. In that month the writer, a member of the Kansas City Amateur Astronomers and Telescope Makers Society, took up regular observations here in Kansas, and since then has sent monthly reports to Holland. Data of some importance has apparently been procured, for Professor van der Waerden writes:

"Your complete records concerning the last visibility of Antares on October 28th and of Arcturus on November 5th will be of great value. . . . I am very happy with your carefully recorded observations."

Who could ask for a better reward?

ROBERT G. McARTHUR
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Kansas City 2, Kan.

THAW-PIERCE FELLOWSHIPS

Princeton University is considering the establishment of a memorial fund in honor of the late Newton L. Pierce, according to Dr. Lyman Spitzer, Jr., director of Princeton University Observatory, who describes Dr. Pierce's lifework in a recent issue of ***Popular Astronomy***. Such a fund will probably be combined with the Thaw fellowship fund and be used to support able young graduate students in astronomy. Contributions to the Pierce memorial will enable this goal to be reached.

Plate I. A region of Cygnus photographed through an interference filter transmitting the hydrogen-alpha line and adjoining wave lengths. Note that the entire field is more luminous than in the picture opposite, indicating the presence of very diffuse hydrogen in this part of the Milky Way.

Glowing Hydrogen in the Milky Way

By Otto Struve, *Berkeley Astronomical Department University of California*

THE EXISTENCE of large fields of nebular emission, far exceeding that of the catalogued nebulae, was first demonstrated with the nebular spectrograph of the McDonald Observatory, in 1938. Since that time B. Strömgren and several other astronomers have made various attempts to photograph or otherwise record even fainter emissions.

Plates I and II were recently obtained by Strömgren and C. Fehrenbach at the Haute Provence Observatory near St. Michel, in southern France. The exposures were made simultaneously, through twin cameras of 50 millimeters aperture and 70 millimeters focal length. In front of each camera the observers had mounted an interference filter: that for Plate I was centered on the hydrogen line Hα and transmitted a range of about 150 angstroms, while that for Plate II was centered at wave length 6200 and transmitted about the same range of wave lengths. The exposures were two hours and the emulsion was Eastman 103a-E.

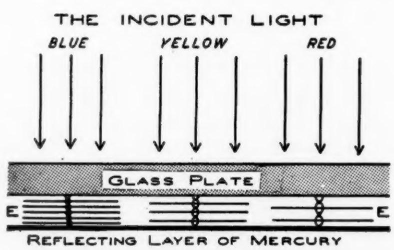
Since the background of the night sky, of the unresolved stars, and of the starlight diffusely scattered by the interstellar dust particles, is nearly the same for both pictures, the difference between them is due to the hydrogen emission in the Milky Way. And, indeed, this difference is enormous. We see in both photographs α, γ, and ε Cygni (also some defects caused by reflections in the optical parts). But while Plate I is more-or-less covered with irregular nebulosity, Plate II shows none at all.

Of particular interest in connection with these observations is the use of interference filters. In astronomical language, a filter is any optical device which transmits a limited range of wave lengths and absorbs light of all other colors. A piece of red glass is a filter; and many previous workers have helped to extend our knowledge of the emission nebulae by means of red-glass filters, transparent to Hα, mounted in front of photographic plates whose wide range of sensitivity included Hα. But as a rule these filters transmit a large range of wave lengths on both sides of the hydrogen wave length. Hence, the contrast between the Hα emitting regions and the normal background of the sky is less than it would be if the filter could be made to isolate a smaller portion of the spectrum.

How important this may be is demonstrated by the use of special, birefringent (polarization) filters in solar research. B. Lyot, Y. Oehman, J. Evans, and others have successfully prepared and used such filters transmitting as little as one angstrom unit; and by doing so they were able to discard the clumsy spectroscopic technique in the observation of solar prominences. But these special filters have small apertures, and they are wasteful of light. They are not yet adapted to the study of the faint interstellar glow of hydrogen gas.

Until recently, interference filters also were too small in aperture to be useful for direct photography. They were first used for astronomical purposes by W. Baade and R. Minkowski, who isolated, with the help of such a filter, a narrow emission line in the Orion nebula. More recently, J. G. Baker has successfully experimented with interference filters at Harvard Observatory. By 1946 their manufacture had been greatly simplified, principally at the Zeiss works in Jena, Germany, where the evaporation process was employed to produce transparent layers of even thickness. This removed the laborious and delicate adjustments required in the earlier forms of the filters. But even then "lack of interference filters of adequate size for even initial explorations" compelled Baker to continue his work with "the best combinations afforded by glass and Wratten filters." (See also *Sky and Telescope*, VI, 5, page 11, March, 1947.)

The disadvantage of size, however,



The principle of the Lippmann color process. Standing waves are set up in the emulsion, E, their separation depending on the wave length of the incident light. Upon development, silver layers are deposited in the anti-nodal planes marked by the horizontal lines.

has now been overcome, as shown by Plates I and II. In fact, Strömgren hopes, in the near future, to use filters of 6-inch aperture.

Anyone who has seen the brilliant colors that are often present when light is reflected from a soap bubble, or from a thin layer of oil floating on water, is acquainted with the phenomenon that is embodied in the interference filter. An even more striking resemblance is provided by the early, and now abandoned method of color photography which was invented by G. Lippmann in 1881. In that process a fine-grain photographic emulsion is covered with a reflecting layer of mercury. The image is photographed through the glass side, and the different rays of light, of all possible colors, penetrate the nearly transparent emulsion until they reach the mercury surface and are reflected by it. The reflected rays interfere with the incident rays, causing a pattern of standing light waves in the emulsion. Thus, inside the photographic emulsion a series of parallel layers is created in which the silver bromide of the plate is decomposed by the action of light, while the intermediate layers, upon development, remain transparent. When the incident light from the object is violet, the wave lengths are short and the standing waves and resultant layers are packed close together. When the light is red the separation between them is greater. Up to this point there is no real difference between the Lippmann plate and one used in ordinary black-and-white photography. Intensely bright objects cause a heavy deposit of silver in each of the layers, while a feeble source leaves most of the silver bromide unaffected — and therefore transparent.

But now imagine that we shine white light upon the developed Lippmann plate. The incident rays again penetrate first through the glass, and then, with decreasing intensity, to each of the parallel layers of developed silver grains in the emulsion. If the original rays that produced the particular layers were red, as from a red brick house, then only red rays out of the white light we are using for illumination will have the correct wave length to become reinforced through interference in the parallel spaces between the silver layers. Blue light will not be in phase, and it will be reflected feebly, or not at all. Thus, the Lippmann plate would act as a red filter, by reflection, if the original object we had photographed was red. It would reflect blue light, however, if we had made our exposure by pointing the camera at the clear daylight sky.

Now, a reflection filter may be useful in some cases. But normally we prefer to use a transmission filter, through which the rays can pass unhindered when they have the precise color for which it is intended, while light of all other colors is effectively removed. This is accomplished in the interference filters which are now commercially available.

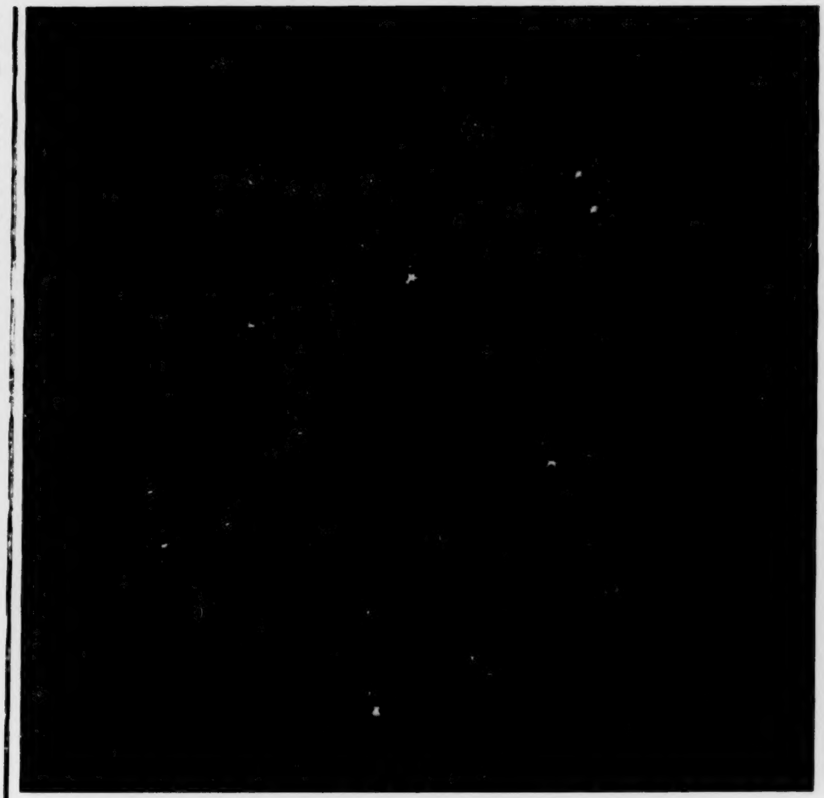
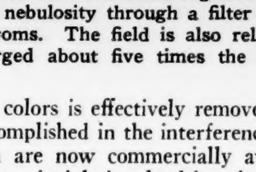


Plate II. The same region of Cygnus as that shown opposite appears devoid of nebulosity through a filter transmitting wave lengths centered at 6200 angstroms. The field is also relatively faint. These photographs have been enlarged about five times the scale of the St. Michel Observatory negatives.

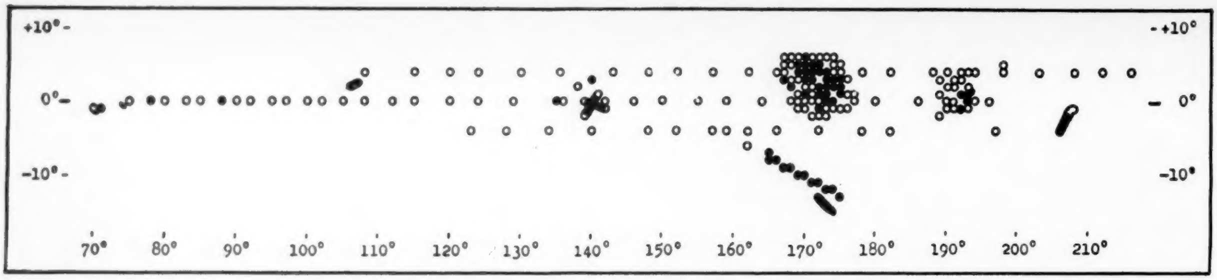
The principle involved is quite similar to that of the Lippmann plate. Two transparent glass plates are separated by a parallel layer of some properly chosen transparent substance. The inner surfaces of the glass plates are lightly silvered, so that they reflect a portion of the incident light. The source may have white light. Its rays penetrate, partly, into the space between the glasses and are there reflected back and forth, with diminishing intensity, on the silvered surfaces. At every reflection some light passes through to the outside, and the resulting transmitted beam is the composite of many individual beams, some having traversed only once or twice between the glass plates, while others may have been reflected back and forth many times.



The principle of the Fabry-Perot interferometer. Interference filters have a layer of transparent dielectric instead of the air space.

If the effective light path between the glasses is properly chosen so that it is an exact multiple of the wave length of light we wish to transmit, only those light beams that have that particular wave length, or color, will reinforce one another, and will pass with considerable intensity. Light of other colors will experience more and more destructive interference: the crest of one wave will combine with the trough of another, and this will impede their passage through the filter.

The entire arrangement resembles that which is used in the famous interferometer etalon of Fabry and Perot. This instrument also uses two parallel glass plates, half-silvered on their inner surfaces. Strictly speaking, the interference phenomena responsible for the filter action will be present even when the glass surfaces are not silvered, because untreated, polished glass surfaces always reflect about four per cent of the incident light, and accordingly multiple beams will result even then. But it can be shown that when the reflecting power of the surface is correctly chosen — not too strong, and not too weak — the summation of the interfering beams becomes especially sensitive to the wave length of the transmitted light. Even a small change in wave length suffices then to



At McDonald Observatory, interference filters were combined with W. A. Hiltner's photoelectric photometer to observe hydrogen-beta emission in the Milky Way, shown by the dark circles in this diagram by B. Stroemgren.

extinguish the beam effectively, while in the ordinary, unsilvered interferometer, like the one invented by Michelson, it might still be transmitted with a reduced but none the less appreciable intensity.

Of course any interference filter, or for that matter, interferometer, loses light by reflection to the other side and by absorption in the reflecting metal films. The best filters now available transmit about 40 per cent at maximum, while light 100 angstrom units on each side of the selected wave length is almost completely blocked out. This preferred wave length is chosen beforehand, and a filter once made for it cannot normally be used for light of another color. This is true also of ordinary glass filters.

Except for one thing. When the rays of light from the source are made to pass obliquely through the interference filter, the path within the space inside the filter is increased. Light of the original wave length no longer experiences a buildup. Instead, this happens for some other, longer wave lengths. Hence, in using the interference filter the light must be nearly parallel: The filter must be placed above the image-forming lens or mirror, especially when the latter has a small focal ratio and the rays converge at the focus from very different directions. This places rather severe limitations upon the astronomical use of these filters. They must either be large enough to go outside the objective, or we must rebuild the instrument in order to have a collimated beam inside.

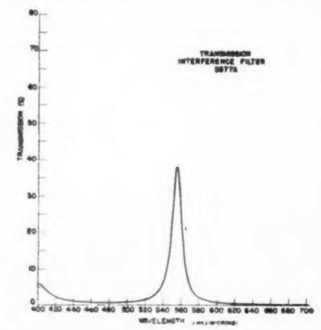
The use of an evaporated film of transparent dielectric between the reflecting surfaces is not necessary in principle. In the original Fabry-Perot etalon an air space between two glass plates was used. But this required extreme precision in the manufacture of the glass surfaces and in their adjustments. It was found easier to control the thickness of the space by depositing a transparent film by means of the evaporation method.

The latest photographic observations by Strömgren and Fehrenbach have not yet been evaluated, but the former believes that their technique will photograph hydrogen regions in the Milky Way that are several times fainter than any that can be recorded with the ordinary glass filter technique or with the nebular spectrograph.

At first sight, it is surprising that any filter should surpass the nebular spectrograph. After all, the latter has a resolving power that far exceeds the 150 angstroms of the interference filter. The gain arises from the fact that the spectrograph fails to produce a complete image of the nebulosity, and thus is unable to show the existence of nebulosity from the faint nuances in contrast that aid the eye in the examination of a direct photograph. It is as though we were to find a nebulosity from the study of a narrow strip, say half a millimeter wide, in Plate I.

An even more promising technique, also using interference filters, was employed by Strömgren and Hiltner at the McDonald Observatory, in 1947. The surface brightness of the sky was measured with the latter's photoelectric photometer, which for this purpose was attached to the 82-inch telescope in order to permit the observers to eliminate the direct light of all stars down to about magnitude 16 or 17. Because of the properties of the photomultiplier cell (RCA 1P21), one interference filter was centered at Hβ (wave length 4861); the other, for comparison, at wave length 4610. The band width of transmission was about 200 angstroms for each filter.

The results of this work have not yet been published in detail, but a preliminary account of it was given by Strömgren in the *Tycho Brahe Arsbok* for 1949. Despite the fact that Hβ is several times weaker than Hα, and that the transmission of the filter was such as to admit 200 angstroms of continuous night-sky light, the photoelectric procedure recorded as definitely present all of the emission regions previously discovered with the nebular spectrograph and some fainter ones. The weakest emission definitely established was about 20,000 times weaker than the central portions of the Orion nebula. The accompanying schematic map of a part of the galactic circle shows as black dots regions which contain glowing hydrogen, and as open circles regions in which the hydrogen glow could not be measured with the Hβ technique. The abscissas are galactic longitudes, the ordinates galactic latitudes. At 170° in longitude, we observe a large emission region between $-1°$ and $+6°$ in latitude. This is in Monoceros. At $-7°$ to $-16°$ in latitude we have the extended emission field of Orion.



The efficiency curve of an interference filter that is peaked at 5577 angstroms, with nearly 40 per cent transmission.

In a general way, these results confirm those obtained with the nebular spectrograph. There are vast spaces in the Milky Way that are filled with hydrogen (and other atoms) having densities between one and about 20 hydrogen atoms per cubic centimeter. Only in exceptionally dense regions — which occupy an exceedingly small fraction of interstellar space — is the density as great as in the Orion nebula — about 1,000 or even 10,000 atoms per cubic centimeter. (Contrast this with the number of atoms in one cubic centimeter of air at the surface of the earth, 3×10^{19}.)

The emission of light by hydrogen is caused by the ionizing action of the extreme ultraviolet radiation of the *O* and *B* stars. In those regions where such stars abound the interstellar hydrogen is mostly ionized, and we call these regions, following Strömgren, the H II regions. The emission of radiation occurs every time an ionized hydrogen atom (a proton) recombines with a free electron.

In regions which are devoid of *O* and *B* stars the hydrogen atoms are neutral. There is no glow from these unexcited atoms, and we have no direct means of

(Continued on page 63)

Photographing Stars in the Daytime

By J. A. Hynek, *McMillin Observatory, Ohio State University*

THE STARS shine just as brightly in the daytime as they do at night, but their light is lost in the overpowering blue glare of the daylight sky. Starlight is not really *lost,* as one might think casually; Pettit and Nicholson showed years ago, by means of a thermocouple placed at the focus of the 60-inch telescope at Mount Wilson Observatory, that the same amount of starlight reaches the surface of the earth during the daytime as at night.

Nevertheless, starlight is effectively lost during the daytime, and the problem is to devise ways of detecting and recapturing the elusive rays we know are reaching us. We shall not pause to ask why anyone should wish to photograph stars in the daytime. Let us simply regard this as a problem arising from natural curiosity.

The eye alone cannot do it. Contrary to much popular opinion, *stars* (not planets) cannot be seen from the bottom of deep wells, while the sun is above the horizon. First, calculations show that even a 1st-magnitude star falls below the threshold of sensitivity of the eye against a daylight sky. To verify such calculations, I once took several members of my astronomy class into a temporarily abandoned smokestack 235 feet high and having an upper opening of 16 feet, thus admitting a circle of sky about two degrees in radius. We entered sufficiently early so that our eyes might become dark-adapted before Vega was scheduled to cross the meridian close to the zenith. Columbus, Ohio, has a latitude of 40° north, and therefore Vega (declination 39°) crosses about a degree to the south of the zenith. At the critical time we looked up, but the sky through the opening appeared just as bright as the sky outside; Vega was not seen by any of us, though one or two students even tried using binoculars. The sky was just too bright!

Just how bright is the daylight sky background? (We say background, but really it is foreground, because all save a very minute fraction of the starlight's journey is on the other side of the atmospheric glare curtain — the daylight sky is something that is "added" at the very end.)

Suppose we imagine all the daylight sky blacked out except for one tiny spot, one second of arc in diameter. This remaining sky-speck would shine like a very blue star of visual or yellow magnitude +4.0, on the average. Its photographic or blue magnitude would, of course, be numerically less. And in the near infrared, the magnitude of our "sky-star" would be numerically greater — generally between +5.0 and +6.0. Numerous independent measurements of sky brightness have been made which, when reduced to stellar magnitudes per circular second, are remarkably in accord.

It is interesting to note that the average value for the visual magnitude of a circular second of dark night sky is about +22. Thus the bright daylight sky is some 18 magnitudes or nearly 16 million times brighter than the night sky. Small wonder then that starlight seems completely swamped out by such overpowering competition. It is only because a circular second of sky is so small (a penny viewed from a distance of 2 1/3 miles subtends an angle of one second of arc) that its magnitude can be as faint as +4.0.

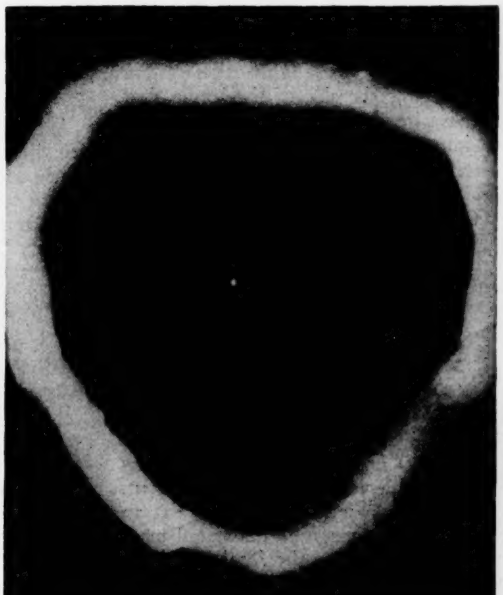
Is there any way, at the telescope, that the brightness of the sky can be made still less? Unfortunately, there is no "magic light trap" that can block sky light and let starlight through. Still, some reduction can be made. The light of the sky is sensibly polarized — at 90 degrees from the sun, and in infrared light, polarization can be as great as 75 to 80 per cent. Under most favorable conditions, then, sky brightness can be reduced about three or four magnitudes below its blue value of about +3.5 per circular second. Furthermore, as we go to higher altitudes, sky brightness decreases. If we go high enough, our problem vanishes! Even at the altitude of Mt. Wilson, the overall sky brightness is more than a magnitude less than it is down at sea level.

Starlight must compete with sky light for a place on the photographic plate. If it wins, it gains enough more developable grains at a certain small spot on the plate than the sky gains at the same spot (and all over the plate) to enable the eye to distinguish this spot from all others. In short, we have the photographic image of a star.

If the star loses, its feeble light was not able to capture enough extra photographic grains to call the eye's attention to the spot on the plate where the telescope focused the light of the particular star.

How many more grains than the average over the plate are necessary so that the eye will concede that there really is a star image there? This is not at all a simple question. To make a long story short, the image *must not be too small*; the eye can distinguish slight differences in density only when the areas compared are relatively large. A fine point can be distinguished from the background only when its total density is considerably greater than that of the background. By and large, the star image must have about once again as much light as is contained in the equivalent area of the sky image.

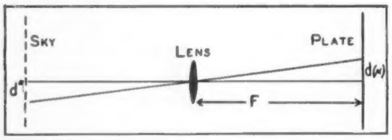
The actual image of a star on a plate is never truly pointlike, nor is it the simple diffraction disk. The sensible disk a star shows on a photograph is the combination of the seeing or "shimmer" disk caused by atmospheric unsteadiness, and the "turbidity" disk



On November 6, 1950, at 3:00 p.m., EST, Roger Hosfeld, a student at Ohio State University, took this photograph of Polaris through the 12½-inch refractor of the McMillin Observatory, focal length 180 inches. Contrast Process Panchromatic emulsion was used, with a red filter, exposure about 1/10 second, developed in D-11. The original star image is 65 microns in diameter, enlarged here about 27 diameters. Also enlarged to form the irregular white band is an ink-marked "circle" centered on the star.

caused by scattering of light by the photographic plate itself. Actual stellar image diameters given by photographic telescopes under the best conditions seldom are less than 30 microns (a micron is a thousandth of a millimeter), and are frequently even greater. Even with fairly short focal-length instruments, 20 microns represents a minimum size of stellar images. Fifty microns might be chosen as a more realistic value, especially as smaller images than this are increasingly difficult for the eye to discern.

To how many seconds on the sky does an image of 50 microns correspond? We must know this to know how much sky light the star is competing with. In the diagram, let the image disk of d microns be projected back onto the sky.



On the sky, the angle d is expressed in seconds of arc; on the plate it is measured in microns, or thousandths of a millimeter.

The simple approximate formula, $d'' = 200\, d\ (\mu)/F$, if F is given in millimeters, serves to connect linear size on the plate with angular size on the sky.

In the following table are listed the number of circular seconds of sky corresponding to star images 20 and 50 microns in diameter, respectively, for telescopes of various focal lengths, and equivalent visual stellar magnitudes of the sky elements in question, assuming that one circular second of arc equals the brilliance of a 4th-magnitude star. Values in brackets are not attainable in practice under average daytime seeing conditions, because with these long focal lengths the size of the seeing disk itself is already larger than the value of the image assumed in the calculations.

Focal Length (inches)	*Area of Sky* 20μ	*Area of Sky* 50μ	*Equiv. Mag.* 20μ	*Equiv. Mag.* 50μ
3	52.6	130.8	−4.3	−6.3
12	13.2	33.0	−1.3	−3.3
50	3.1	7.9	1.8	−0.2
100	1.6	3.9	3.3	1.3
180	0.9	2.2	[4.6]	2.5
300	0.5	1.3	[5.6]	4.3
500	0.3	0.8	[6.7]	[4.8]

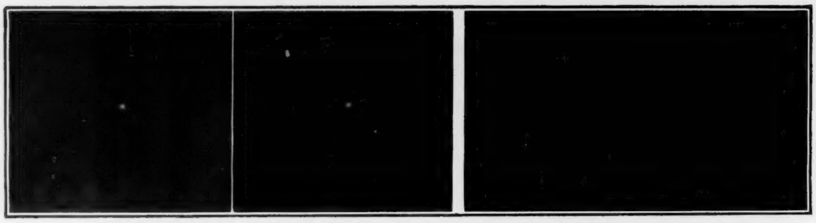
What does the table imply? It states only that *if* images of 20 or 50 microns are attainable with a given instrument, then these images compete with an equivalent sky image of the stated magnitude. The longer the focal length, of course, the larger the image of the star, since the nearly pointlike star is transformed into a tremor disk by the atmosphere.

The table can nevertheless be used as a guide. In practice, for any given instrument, one must measure the images obtained at night, and apply the simple formula directly, making due allowance for the fact that seeing in the daytime is generally much worse than at night. We can readily see, however, that long focal-length instruments are necessary, because both photographic and physiological factors enter to limit severely the size of the threshold image for short focal-length instruments. In such instruments the threshold image must compete with an overwhelming amount of sky light, as the table readily shows, and hence focal length is a primary factor in this problem.

Formulae can easily be developed to take into account the aperture of the instrument, contrast of the plate, seeing, and the turbidity of the emulsion. Development of such a formula is beyond our scope here, but the results it yields are of the same order as those given by our simple formula. The formula works also for night photography. The night sky has a magnitude of about +22; hence, if we add 18 to the values in the table we should arrive at the approximate limiting magnitude at night. The time required to attain this limit will, of course, depend on the aperture of the instrument.

A large aperture reduces the diffraction disk of the star, but for almost all instruments this is already smaller than the average seeing disk. Further, seeing conditions in the daytime can be incredibly bad, in which case images of 50 microns even with short focal-length telescopes are not to be expected. Our formula holds only for cases in which images of a given diameter are assumed. Finally, a nominal contrast has been assumed.

The greater the contrast of the photographic plate, however, the easier it is for the eye to distinguish a star from its background. If, indeed, a plate had a contrast sensitivity of one per cent, that is, if it could make visible a source that had but one per cent of the light of the background $[(100+1)/100]$, stars that are five magnitudes fainter than those indicated in the table could, theoretically, be detected. Unfortunately, photographic plates for astronomical purposes do not have this contrast sensitivity for areas as small as star images.



Stars photographed in the daytime with the 12½-inch refractor of the McMillin Observatory. Those at the left are of Capella, first without and then with an infrared polarizing filter. The elongated image at the right is that of a 3rd-magnitude star, taken in infrared light without a polarizing filter; the circle is an ink mark. McMillin Observatory photographs.

The numbers in the table have been computed for a clear blue sky. The presence of even a slight haze increases sky brightness greatly. The use of polarizing or of infrared filters has not been taken into account. Experiments carried out at the McMillin Observatory with such devices for decreasing the brightness of the sky have so far been rather disappointing. A very great difficulty experienced with the use of infrared plates was the incredible number of spurious stellar images, which even under a microscope were difficult to distinguish from the real thing. This made positive identification of fainter stars almost an impossibility.

The use of polaroid filters, however, represented some improvement. Two of the pictures above show Capella photographed in bright daylight without and with the use of an infrared polarizing filter. Also reproduced here is an infrared photograph, without polarizing filter, of a 3rd-magnitude star; the image is elongated.

Results almost as good have been obtained in practice by the use of high-contrast commercial panchromatic plates and a yellow or red filter. Polaris was photographed in bright daylight by one of our students, Roger Hosfeld, with an exposure of about 1/10 second.

We have said nothing so far about the spectral classes of the stars. Obviously, if infrared techniques are used, stars of late spectral types are the logical choice. A star whose spectral energy curve rises farthest above that of the sky at wave length 8000 angstroms will be most easily photographed. *K*-type stars have their energy maximum in this spectral region, and hence are the most effective stars for this purpose. In terms of visual magnitudes, however, the faintest stars photographable will be late *M*-type stars.

The greatest promise for the daylight photography of stars lies in the development of high-contrast, stable, and essentially flaw-free infrared photographic plates.

Amateur Astronomers

THIS MONTH'S MEETINGS

Cambridge, Mass.: The Bond Astronomical Club will meet jointly with the Amateur Telescope Makers of Boston on Thursday, January 11th, 8:15 p.m. at Harvard Observatory, when Ivan King, of the observatory, will speak on "Astronomy in South Africa."

Chicago, Ill.: The Burnham Astronomical Society will meet at the Adler Planetarium on Sunday, January 14th, at 4:00 p.m. A. V. Shatzel, Adler Planetarium, will speak on "Ancient Astronomical Instruments."

Cleveland, Ohio: "Star Clusters in the Milky Way" will be the subject of Dr. Donald A. MacRae, of the Warner and Swasey Observatory, when he speaks at the January 26th meeting of the Cleveland Astronomical Society, 8 o'clock at the observatory.

Dallas, Tex.: Walter L. Oliver will demonstrate "The Phenomena of Light," at the January 22nd meeting of the Texas Astronomical Society, Dallas Gas Company auditorium, at 8 o'clock. The public is invited.

Detroit, Mich.: A panel discussion by members of the Detroit Astronomical Society on "What Amateur Telescope Making Has Meant to Me" will be held at the society's annual meeting, January 14th, 3:00 p.m., in State Hall of Wayne University. There will be an exhibition of telescopes.

Geneva, Ill.: At a symposium before the Fox Valley Astronomical Society on Tuesday, January 2nd, 8 p.m. in the Geneva City Hall, Clarence R. Smith will speak on "The Geologist at Work," and Frank Hancock on "Causes and Effects of Earthquakes."

Indianapolis, Ind.: Paul Richey will have as his subject, "Creation," at the January 7th meeting of the Indiana Astronomical Society, 2:30 p.m. in the Riley Library.

Madison, Wis.: Star clusters will be discussed at the January 10th meeting of the Madison Astronomical Society, at Washburn Observatory at 8:00 p.m. Bob Burkhalter will speak on globulars; Fred Ehrensperger, on open clusters; Leslie Ketchum, on moving clusters.

New York, N. Y.: "The American Tradition in Astronomy" will be discussed by John W. Streeter, of the Fels Planetarium, at the January 3rd meeting of the Amateur Astronomers Association, 8 o'clock in the Roosevelt Memorial building of the American Museum of Natural History.

Rutherford, N. J.: At the January 4th meeting of the Astronomical Society of Rutherford, 8 p.m. in the Y. M. C. A., Mrs. Willard B. Savary will speak on "Observatories," and Mr. Savary will discuss "The Outer Planets."

Washington, D. C.: Dr. John P. Hagen, of the Naval Research Laboratory, will speak on "The Measurement of Solar Radiation at Radio Frequencies during the Total Eclipse of the Sun, 12 September 1950," at the January 6th meeting of the National Capital Astronomers, 8:00 p.m. in the Commerce Building auditorium.

Worcester, Mass.: At the meeting of the Aldrich Astronomical Society, Tuesday, January 2nd, at 8 o'clock in the Natural History Museum, Dr. Charles Hetzler, of Ladd Observatory, will speak on "Nature's Temperatures."

PROMINENT AMATEURS DIE

The man who gave the Astronomical League its present name, by his proposal at the Philadelphia convention in 1947, Frederick H. Cox, died in Norfolk, Va., November 20th, at the age of 82. He was an active member of the Norfolk Astronomical Society and the representative of that group on the Middle East regional council. Some years ago he was appointed historian of American Legion Post No. 36, an office he held at his death.

A leading member of the Portland Astronomical Society, Charles G. Benson, died in Portland, Ore., on October 30th, at the age of 71. As an attorney, he gave the Astronomical League important assistance in legal matters, and he was vice-chairman of the Northwest region until last summer.

Carl Wanek, a charter member of the Buffalo Amateur Telescope Makers and Observers, died at the age of 60 on October 22nd. A mechanical engineer by profession, he was one of the first amateurs in the Buffalo, N. Y., area to complete reflecting telescopes of 6-inch and 10-inch apertures. The 10-inch instrument is at present in operation at the Dow Observatory in East Aurora, N. Y., where members of the Buffalo group make frequent use of it.

GLOWING HYDROGEN IN THE MILKY WAY

(Continued from page 60)

establishing the presence of any hydrogen in them. But we can observe in these H I regions, as well as in the H II regions, the effect of absorption produced upon starlight penetrating through them, by interstellar atoms of sodium, calcium, and so on. These interstellar absorption lines were known even before the hydrogen emission regions were discovered. But their interpretation became possible only when we understood that in interstellar space, as in the sun and the stars, hydrogen is by far the most abundant constituent.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.
SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evening, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BOSTON: *Little Planetarium.* Boston Museum of Science, Science Park, Boston 14, Mass. Richmond 2-1410.
SCHEDULE: Tuesday thru Friday at 3:30 p.m.; Saturday, 2:00 and 3:30 p.m.; Sunday, 3 and 4 p.m. Spitz projector. In charge, Charles A. Federer, Jr.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.
SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.
SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.
SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.
SCHEDULE: Wednesday and Saturday, 3:30 p.m.; Sunday, 3:00 and 5:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.
SCHEDULE: Wednesday and Thursday at 8:30 p.m.; Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.
SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Acting Chairman, Robert R. Coles.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.
SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.
SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Spitz Planetarium.* Oregon Museum of Science and Industry, 908 N.E. Hassalo St., Portland 12, Ore., East 3807.
SCHEDULE: Tuesday through Sunday, 4:00, 7:30, and 8:30 p.m.; Saturday show for tots, 10:30 a.m. Special group lectures by request. Spitz projector. Director, Stanley H. Shirk.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.
SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.
SCHEDULE: Sunday, 4:15 p.m. Special showings on request. Admission free. Spitz projector. Director, Robert E. Cox.

NEWS NOTES

By Dorrit Hoffleit

NEW YERKES DIRECTOR

Dr. Bengt Strömgren, Danish astrophysicist and until now the director of the Copenhagen Observatory (where he succeeded his father in that post in 1940), becomes director of the Yerkes and McDonald Observatories at the beginning of this year. He succeeds Dr. Otto Struve, who has gone to the University of California.

Dr. Strömgren received in 1949 the $5,000 Augustinus prize for his accomplishments in astronomy and astrophysics. Although many foreign-born astronomers are now directors of American observatories, this is the first time that one has been called directly from helm to helm across the seas.

STRANGE SCULPTOR SYSTEM

On plates taken at Harvard's southern station in 1935, Dr. Harlow Shapley discovered a very strange system of stars in the constellation of Sculptor. At Mount Wilson Observatory, Drs. Walter Baade and E. P. Hubble found in the system some 40 variables that they supposed to be of short period. On this basis Shapley estimated the intrinsic brightness of the variables; their extreme faintness in the sky placed the Sculptor system at roughly 260,000 light-years from us — in intergalactic space far above the pole of the galaxy. Was this then a galaxy or a huge globular cluster?

Now Dr. A. D. Thackeray, at the Radcliffe Observatory in South Africa, has studied the object on 45 plates taken with the 74-inch reflector. From only 12 pairs of plates 216 variable stars have already been found, and it is estimated very roughly that 700 variables might be discovered in a complete survey. For 33 variables provisional periods are mostly between 0.5 and 0.7 day — typical cluster-type variables that predominate in ordinary globular clusters. Three are unusual with periods close to one day. Thackeray concludes his report in *The Observatory* for August, 1950:

"The new facts listed above suffice to show the remarkable similarity of the Sculptor system in some particulars to globular clusters and to underline the essential uniformity (or if one prefers to look for minor differences the diversity) of nature in regions extending outside our own Galaxy. If Omega Centauri were blown out to thirty times its actual size and removed to ten times its distance, its appearance would be very similar to that of the Sculptor system. But the frequency-distributions of periods differ in such a way as to indicate some physical dissimilarity which may be highly significant."

A diagram originally published in Harvard "Bulletin" 908 to illustrate the distribution of the stars in the central square degree of the Sculptor system. The number of observed stars in each 25 square minutes of arc is represented by two fifths as many dots. At distances less than 20 minutes from the center the cluster is noticeably elongated in an east-west direction. The total diameter of the entire system is not less than 80 minutes, and may be as great as two degrees; it contains 15,000 stars to the 20th magnitude.

PALOMAR IS POPULAR

The public relations office of the California Institute of Technology reports continued interest of the public in the 200-inch telescope. Approximately 100,000 people ranging from eight to 80 years old visited Palomar last year, the same number as the year before. They came from all over the world, sometimes by the busload, as in the case of a junior high school group that traveled the 500 miles from Phoenix, Ariz., just to look at the telescope. Mrs. Dorothy K. Smith, of the public relations department, writes, "Our letters asking for information increase rather than decrease."

The National Geographic Society quotes Palomar's director, Dr. Ira S. Bowen, as saying, "More than any other science, astronomy gives us a true perspective of man's place in the universe.

"Not long ago a high official in the federal government requested an enlarged photograph of one of the spiral galaxies far out in space. 'In a continually tense situation it is often difficult not to take ourselves and our immediate problems too seriously,' he wrote. 'I want to hang this picture in my office, so that when the going gets tough and the immediate problem seems unusually important and urgent, I can just take a look and regain my sense of proportion.' "

In the CURRENT JOURNALS

AMATEUR PHOTOMETRY, by William A. Baum, **The Griffith Observer,** November, 1950. "The development of the photomultiplier is good news to the amateur astronomer. It is a powerful tool, relatively simple to operate yet remarkably accurate, by which he can conduct a serious observing program."

PROBLEMS IN THE SPECTRA OF NOVAE, by Dean B. McLaughlin, **Publications** of the Astronomical Society of the Pacific, October, 1950. "Since the beginning of nova spectroscopy with T Aurigae about fifty-eight years ago, spectroscopists studying novae have discovered many more questions than answers."

AN ANALYSIS OF TIDES AND CURRENTS, Part 1, by Frank H. Browning, **The Ensign,** November, 1950. "And yet we find surprising discrepancies in the attempts of current literature to explain the manner in which lunar and solar attraction generates these tides. They do violence to the established laws of force and motion-dynamics."

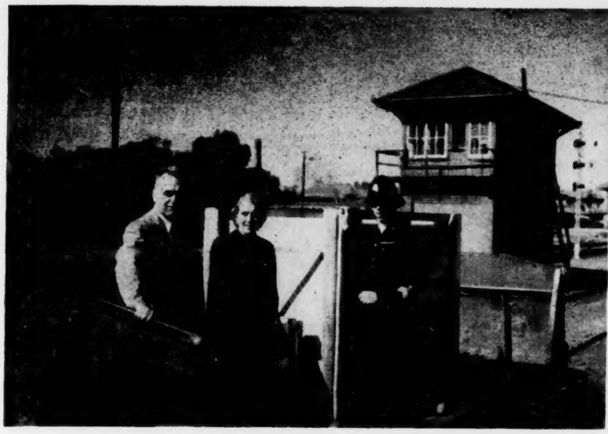
UPPER ATMOSPHERE NOMENCLATURE

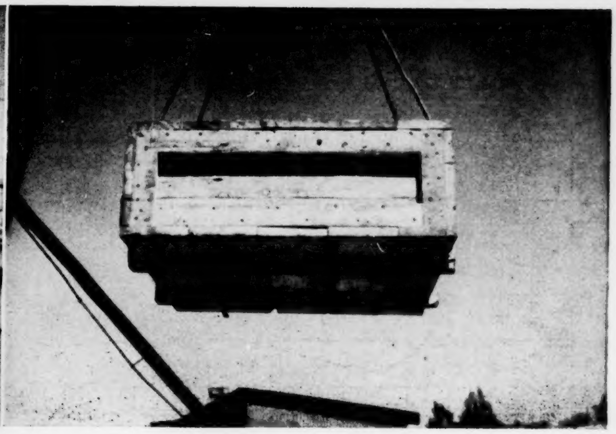
In its October, 1950, issue, the *Bulletin* of the American Meteorological Society carries an article on the terms used to describe parts of the earth's upper atmosphere. It is written by no less an authority than Sydney Chapman, of Oxford University, now on leave at California Institute of Technology. His nomenclature differs from that of H. Flohn and R. Penndorf outlined on page 185 of the June, 1950, issue of *Sky and Telescope,* also based on an AMS *Bulletin* article.

For the term *stratosphere* Chapman would prefer to keep the original meaning of the nearly isothermal region above the troposphere, despite its occasional use in recent years to mean any level above the troposphere. He advocates greater application of the suffix *pause,* as used by Sir Napier Shaw in the term *tropopause,* for signifying the upper boundary of a region. The upper boundary of the stratosphere, "where the temperature first begins to increase upwards more rapidly than is common in the lower stratosphere, would be the *stratopause,* and the mesosphere would extend from this level to the *mesopause,* at the level of the deep temperature minimum." Above the mesosphere would be the *thermosphere,* in which the temperature increases, but whether or not a *thermopeak* exists is unknown.

Chapman suggests that the *neutrosphere* is below the *ionosphere,* that the *homosphere* extends from the ground to the region where the composition of the atmosphere first begins to change materially — the *heterosphere.*

Chapman agrees with astronomers C. T. Elvey and Otto Struve in the term *airglow* to signify the light *emitted* by the atmosphere, other than the aurora and lightning. The non-auroral light of the night sky would thus be called the night airglow.





Dr. and Mrs. Bart J. Bok attend the arrival of the ADH telescope at the railroad station on October 26th (left). Unloading the crate containing the 36-inch primary mirror (right). Photographs by Uco van Wijk.

ADH IN OPERATION

The Armagh-Dunsink-Harvard Baker-Schmidt telescope, which left New York September 29th on the freighter *African Lightning* of the Farrell Lines, was met less than one month later at East London, South Africa (the seaport nearest to Bloemfontein), by Messrs. Bester and Burton of the Boyden station. The instrument was placed on the mounting of the old 24-inch Bruce doublet.

Adjustments proceeded without a hitch with the aid of detailed directions provided by the manufacturers, the Perkin-Elmer Corporation. Dr. Bok writes, "The telescope responds beautifully to all mechanical adjustments and is as nice as any instrument I have ever handled." In a radiogram from him received December 6th, he states in effect: "Baker-Schmidt adjusted. Star tests show perfectly sharp round images; smallest diameters 35 microns. Fifteen minutes with ADH equal 90 minutes with 24-inch Bruce. Excellent performance on diffuse nebulosities and galaxies. Minor bugs include somewhat variable focus plate to plate."

The instrument's first program is on magnitude standards in selected area No. 193 in Carina (see page 56).

COMET KOPFF

F. Kepinski, of the Warsaw Technical University, has published a search ephemeris for periodic Comet Kopff (1906), last observed in 1945. It is an exceptionally interesting object because it approaches Jupiter possibly more closely than other known members of Jupiter's family, and consequently is subject to great variations in its orbital elements. The ephemeris is based on a system of osculating elements obtained by J. Bobone, of Cordoba Observatory, from observations in June-August, 1945. Kepinski predicts the next perihelion passage as 1951 October 22.44, with the magnitude possibly 13th, although the brightness of the comet seems to vary considerably. The next close approach to Jupiter will probably occur in 1953.

TERMINOLOGY TALKS

J. Hugh Pruett

Star Day and Sidereal Day

The statement is sometimes found that a sidereal day is the exact time it takes the earth to make one revolution on its axis as indicated by sighting on the distant stars. I know of a textbook that errs in this respect. A "star day" is the time of one rotation of the earth — the interval between two successive transits of some certain star across the observer's meridian.

But a *sidereal day* is defined as the time between two successive transits of the vernal equinox. As we shall see next month, the vernal equinox moves westward among the stars approximately 1/100 of a second of right ascension daily. Therefore, this equinox will come to the meridian 0.01 second earlier by star time each successive day, and the sidereal day is that much shorter than the period of one rotation of the earth.

Since solar days are regulated by the sun, which appears to move approximately one degree eastward among the stars daily (four minutes of right ascension) such days are about four minutes longer than sidereal days. A sidereal day is usually given as equal to 23 hours, 56 minutes, 4.091 seconds of mean solar time.

Sidereal Time

For their celestial observations, astronomers require clocks that run slightly faster than civil clocks. Thus, any sidereal time unit, hour, minute, or second, is slightly shorter than the corresponding solar unit. Observatory clocks are set to show *sidereal time*, which is the hour angle of the vernal equinox, that is, its distance west of the observer's meridian.

Sidereal time is therefore a local time, different for every longitude, and the clocks in two observatories differ by an amount equal to their longitude. These sidereal clocks, in turn, differ from local solar time clocks, with their difference being zero at the time of the September equinox and 12 hours at the time of the March equinox.

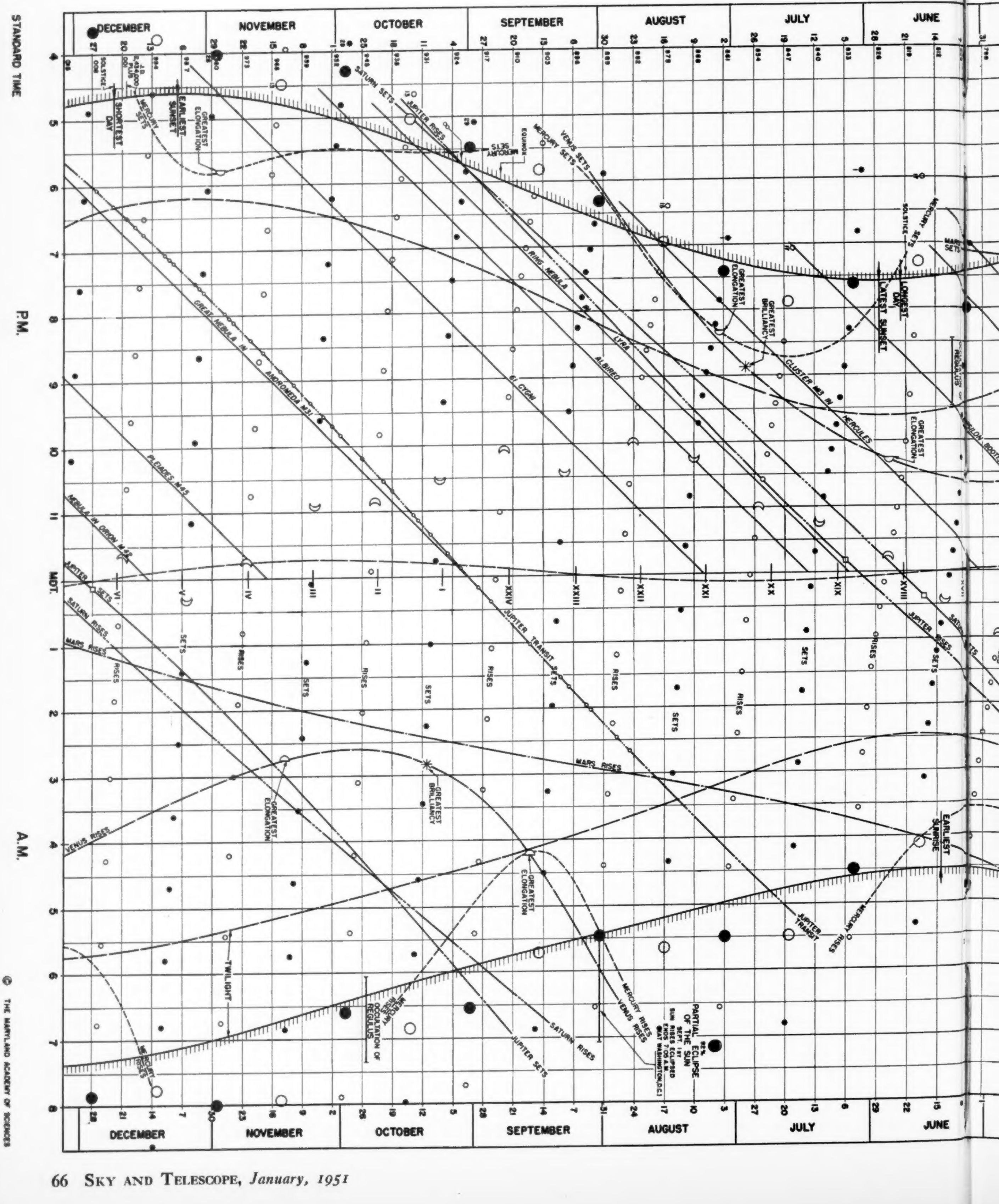
The sidereal day begins when the vernal equinox crosses the observer's meridian. This occurs at midnight at the time of the September equinox, about September 23rd, and then nearly four minutes earlier each day (by a solar clock) throughout the year. This year, on January 1st, the sidereal time is 0^h at 17:17:49 (on the Greenwich meridian) Greenwich civil or Universal time.

It is easy to determine the sidereal time if one has accurate setting circles on his telescope with which to observe the meridian angle of a star east or west of the meridian. For example, the star chart on page 78 shows the vernal equinox four hours west of the meridian. This is the sidereal time for which the chart is drawn. Consider the star Hamal, in Aries, which has a right ascension (given in an almanac) of $2^h\ 4^m.4$. At the chart time Hamal is, therefore, $1^h\ 55^m.6$ west of the meridian. However, were one's setting circles to show the star to be an even three hours west of the meridian, the sidereal time would be $5^h\ 4^m.4$, that is, equal to the sum of the right ascension and the positive meridian angle of the star.

Of course, if a star can be caught exactly on the meridian, the sidereal time is equal to its right ascension, but for accuracy such an observation probably requires a specially built transit instrument, such as employed at observatories where time observations are made.

Graphic Time Table of

PREPARED BY THE MARYLAND



...of the Heavens - - 1951

...RYLAND ACADEMY OF SCIENCES

The Graphic Time Table of the Heavens

while still available may be secured directly from the Maryland Academy of Sciences, Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., at 10 cents each — discount on quantity orders. Blueprints of the original drawing are available at cost — $1.00 each — 40 x 27 inches. A Quebec edition, in French, for 47° N. and 75° W., is also available.

The Graphic Time Table gives the rising and setting times of the sun, moon, and bright planets; the beginning of morning twilight, and the ending of evening twilight; the times when certain stars and other objects of interest transit (cross the celestial meridian); phases of the moon; the equation of time; and other astronomical information. To illustrate by an example: The events of the night of January 4-5 may be found by following the horizontal line for that date across the graph from left to right. The Julian Day number for that evening is 2,433,651. Mercury sets at 4:17 p.m. standard time, the sun sets at 4:48 p.m., and Venus sets at 5:43. Evening twilight ends at 6:24. Mars sets at 7:22; the Pleiades transit or cross the meridian at 8:49; Jupiter sets at 9:03; the Great Nebula in Orion transits at 10:36; Saturn rises at 11:05. The curve for the equation of time shows that the sun is slow and will not be on the meridian until five minutes after 12 o'clock noon, local time, on January 5th. Saturn transits at 5:14 a.m. on the 5th; the moon rises at 5:20; morning twilight begins at 5:45; Mercury rises at 6:40; and the sun rises at 7:22 a.m.

The dashes on the sunset and sunrise curves aid interpolation on intermediate days. Roman numerals show sidereal time at midnight. The phases of the moon are indicated by the conventional symbols. Small black circles show moonset for the first half of the lunar month, and small open circles show moonrise from full to new moon. Circles on the Jupiter transit curve indicate nights on which occultations, eclipses, or transits of Jupiter's bright moons occur between 7:00 and 11:00 p.m. EST. Small squares on planet curves indicate quadrature, and oppositions are marked by the conventional symbol.

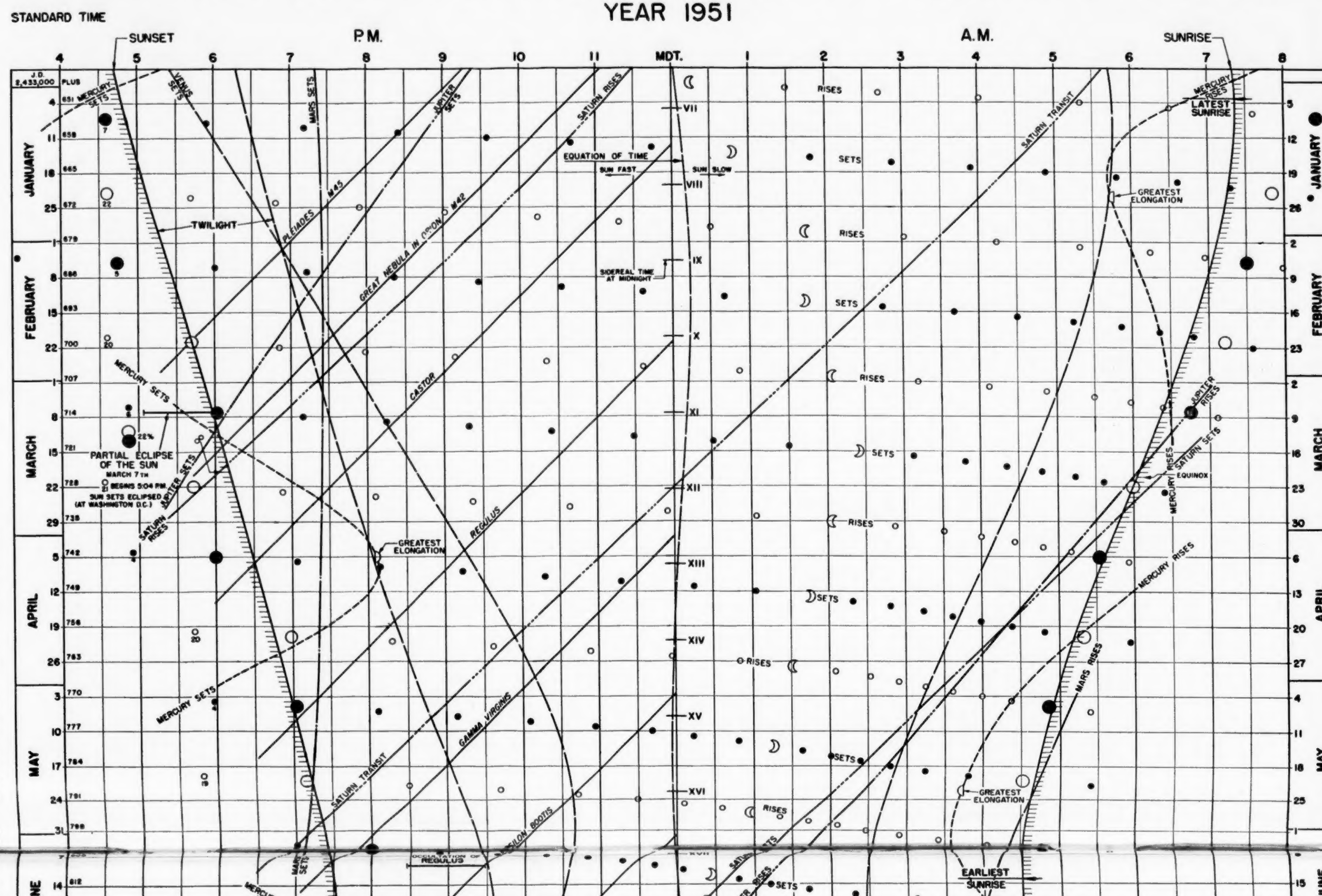
How to Correct for Your Position

As in all almanacs, times of rising and setting of sun, moon, and planets are absolutely correct for only one point on the earth's surface — for this chart: latitude 40° N. and longitude 90° W. The observer may easily correct for his own position. Latitude differences have comparatively minor effect and may in general be disregarded.

Correction for difference in longitude depends principally on the observer's distance east or west of his standard time meridian, which is always at an even multiple of 15°. Some corrections are tabulated here, in minutes of time:

Atlanta	+38	Detroit	+32	New York	— 4
Baltimore	+ 6	Houston	+22	Pittsburgh	+20
Boston	—16	Indianapolis	—16	Rochester	+10
Chicago	—10	Kansas City	+18	San Francisco	+10
Cincinnati	+38	Los Angeles	— 7	Seattle	+10
Cleveland	+27	Milwaukee	— 8	St. Louis	+ 1
Denver	0	Minneapolis	+13	Washington	+ 8

All places with plus correction are west of the standard meridian, and the events will occur later. The usual correction of one hour for each standard time zone must also be made to the Eastern standard times given for lunar eclipses and Jupiter's satellites, and in the Far West slight corrections may be made to times of moonrise and moonset. For times of occultations and solar eclipses, refer to the "American Ephemeris."



BOOKS AND THE SKY

LATIN TREATISES ON COMETS BETWEEN 1238 AND 1368 A.D.

Lynn Thorndike. University of Chicago Press, Chicago, Ill., 1950. 275 pages. $5.00.

WHEN Robert Grant wrote his great **History of Physical Astronomy** in 1852, he dismissed the astronomy of the Middle Ages in two paragraphs. Today, we realize that this neglect was quite unjustified, for the universe and its relation to man held a deep interest for medieval thinkers. In the 13th century the writings of Ptolemy and Aristotle, which had been preserved by Arabic scientists, were reintroduced into Europe, and stimulated a widespread cultivation of astronomy. A very extensive astronomical literature resulted, which however has become largely inaccessible and forgotten by the present age.

Professor Thorndike has taken a prominent part in making medieval scientific literature available to the modern reader. His **History of Magic and Experimental Science** and his **Sphere of Sacrobosco** are invaluable to those who wish acquaintance with the soil from which modern astronomy later sprang.

His present work is a survey of the views held concerning comets in the 13th and 14th centuries. It contains the Latin texts, with extensive notes, of nine treatises on comets, which had hitherto been available only in manuscript, or in the form of brief excerpts. The earliest and longest of these treatises was written by an unknown author in Spain about 1238; the latest is John of Legnano's account of the comet of 1368. In addition, Thorndike has translated into English sections of the writings of Albertus Magnus and Thomas Aquinas which deal with comets.

These treatises are largely concerned with astrological prognostications drawn from comets. As Thorndike remarks: "Most of the treatises here published were occasioned by the appearance of a particular comet. Most of them give some account of its appearance, course, and duration, although this recorded observation and apparent scientific curiosity may be largely motivated by the desire to obtain a sound basis for prediction of the future. But most of them recur to past authorities for the theory of comets and for previous instances of their occurrence."

However, the interest which these works have for modern readers is not limited to the light they throw on how men thought about comets 600 years ago. These texts have further value, for they contain observational data which can be applied to problems of current importance.

A single example of this will be cited very briefly. On page 60 there is a long quotation from the Arab astronomer Haly Abenragel, reporting observations of the comet of 1006. Thorndike does not question that this was a comet, but we may pursue the case further.

This object of 1006 has been variously regarded as a comet (Pingré, **Cométographie, 1,** 363, 1783) and as a nova (Schönfeld, **Astronomische Nachrichten, 127,** 153, 1891). It is often difficult to tell whether old records refer to a comet or to a nova, but we now have evidence that this was a new star, from Haly Abenragel's statement that it was stationary with respect to the stars. He says further that it was as bright as the quarter moon; this statement is confirmed in detail by Japanese records summarized by Yasuaki Iba (**Popular Astronomy, 42,** 251, 1934). So great an apparent brightness raises the question whether we are dealing with a supernova.

This important case merits critical examination. If a galactic supernova actually appeared in the year 1006, its remnants may still be recognizable; while the statements concerning its position are rather indefinite, reconstruction of its approximate co-ordinates is possible.

Professor Thorndike's book is intended for the specialist in the history of science rather than the general reader; nevertheless, his excellent introduction will be found interesting reading by many who would forego the Latin text itself.

JOSEPH ASHBROOK
Yale University Observatory

REFLECTIONS OF A PHYSICIST

P. W. Bridgman. Philosophical Library, New York, 1950. 392 pages. $5.00.

THIS COLLECTION of 22 essays and lectures by an outstanding physicist and scientific thinker is aptly named. For Professor Bridgman has reflected on many problems beside those of thermodynamics and high-pressure physics in which he has made his scientific reputation and earned the Nobel prize (1946). Moreover, these reflections are unmistakably

those of a physicist—of an experimental physicist. They are deeply rooted in the hard-headed, pragmatic philosophy of an individualist who prefers above all else to deal with sensible things, things that can be seen, felt, smelled, heard, tasted, and measured.

The essays have been written over the years 1929 to 1949, three of them, as the publishers are anxious to note, specially for this book. They are not in chronological order, but are collected into five groups: I. "General Points of View," the author's philosophy; II. "Applications to Scientific Situations," an analysis of some fundamental problems in modern science; III. "Primarily Social," the author's views on society; IV. "Specific Situations," concerning his reactions to totalitarianism and the welfare state; and V. "Prophetic," including his view of the future. This grouping results in a remarkably well-organized book, considering the diverse sources of the individual chapters. The author's point of view is first specified and defended, then applied to the limited domain of physical science, and finally applied to the broadest of human problems.

In 1926 Professor Bridgman published **The Logic of Modern Physics,** in which he propounded an "operational" approach to the new physical concepts introduced by quantum mechanics and relativity. The main theme of his reflections is an elaboration of this approach. In the narrowest sense, operationalism denies the reality of any concept the measurement or detection of which cannot be described in terms of actual experimental operations. Carried to such an extreme, and particularly outside the realm of physical science, this point of view can raise more problems than it settles, but in Professor Bridgman's skillful hands it undoubtedly has had — and is having — considerable effect on the development of new physical concepts. However, he admits in the first of his reflections that his original operational idea has mellowed somewhat over the years.

At this point it is worthwhile noting an unavoidable defect in **Reflections of a Physicist:** Many of the essays and lectures were written to answer criticisms of operational analysis; in fact, the second essay is entitled "Rejoinders," and without these criticisms explicitly stated, the book does not unfold to the reader the true depth and extent of the controversy. The view of operational analysis presented is thus necessarily one-sided.

A second point of view which runs through these reflections is Professor Bridgman's monolithic individualism. He believes in the personal nature of scientific advances and of science itself (he distinguishes between "my-science" and "your-science"), which may be refreshing to some readers in these days of research teams, atomic energy commission, and government-supported research, or which may seem antiquated to others. In any case, the concept of individualistic science is made so attractive it may encourage more scientists to build their own equipment, to make their own measurements, and to reach their own conclusions.

The second group of essays contains some clearly written analyses of quantum concepts, of cause and effect, of statistical mechanics and of the second law of thermodynamics. A lecture on the "Time Scale" and an essay on the "Nature and Limitation of Cosmical Enquiries" should be of particular interest to the astronomer as forming a view of the subject by a shrewd and critical outsider. Professor Bridgman here raises some basic problems, such as the undesirable extrapolations in astronomy, and presents some minor conclusions of interest, such as the fact that the Heisenberg uncertainty principle leads to an expected blurring of the identity of two now distinct stars 10^{100} years hence. His great caution and his predilection with experimental science are exemplified by his viewing "with extreme suspicion" the "perfectly scandalous temperatures and pressures" assigned by modern theories to the interior of a star, because "such conditions are so tremendously beyond the range of anything that can be obtained in the laboratory." One may well wonder how he draws the line between these parameters derived from a consistent astronomical theory on the one hand, and, on the other, parameters like nuclear binding energies or the frequencies of X-rays, which might seem scandalously far removed from directly measured chemical energies and radio frequencies.

Whatever the views of a reader, he will find this book clear and thought provoking, with a specificity usually lacking in philosophical discussions.

THORNTON PAGE
Yerkes Observatory

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

A Portable Power-driven Telescope Mounting

After experimenting with several portable mounts built up from parts on hand and finding them all unsatisfactory, I decided to build one from the ground up. The assemblage as a whole (see front cover) consists of an aluminum tripod with an extended equatorial mounting, a smaller tripod for the power unit, which receives its current from an inverter attached to a 12-volt storage battery, all of which weighs 120 pounds.

The legs of the telescope tripod are made of 2½ x 2½ x ¼, 24S-T4 aluminum, and the fork was made from the same material of 1¼ x 6 size. The bolts throughout are machined from naval bronze stock. The bolts holding the legs are 5/8" and provided with heavy washers. All of the bolt heads are of the same size, so that only one socket wrench is necessary. The polar-axis shaft was machined from a bar of 1½" alloy steel. Thirteen precision radial ball bearings are used in the moving parts.

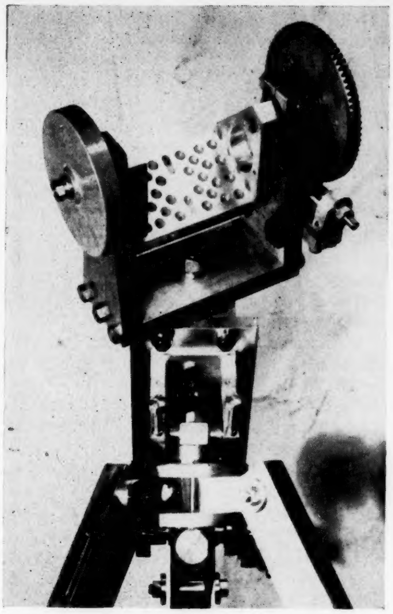
Both large gears are cast iron, mating with hard steel worms. These were lapped to insure smooth operation. The worm at the fork is operated through a universal joint and a long aluminum tube, shown hanging downward. In operation, this tube is suspended from the telescope by a piece of rubber webbing. One end of the polar-axis drive worm is connected to the power drive and the other to a bevel gear. Mating with this bevel gear is a bevel pinion which slides in or out of mesh for hand corrections. To the pinion, through a universal joint, is attached a long tube of aluminum. This is also shown hanging down, and in operation it is also supported with elastic webbing. The gear on the polar axis is bored for a snug running fit and drives the polar axis through two friction disks. The drive is made operative by tightening the nut shown with a bar through it.

The power drive to the worm is through a clutch that has just enough drag to drive the scope without any slip. This clutch is provided with a ball-bearing thrust and adjustable spring tension; it permits hand adjustment while the drive motor is in operation. The dust caps on the annular bearings cause a little drag. When changing speed, the motor is not stopped, and there is but little backlash in the gear train and universal joints—hence, no jerking. The drive shaft connecting the motor unit (on the smaller tripod) to the telescope has a universal joint on each end. The shaft telescopes on a sliding key, and both the hand drive tubes and the power drive shaft work through taper pins that are easily removable.

The power unit tripod is also aluminum. The motor is a 12-watt heavy duty Telechron, 60-cycle, 110 volts. The synchronous speed drives the output shaft of the motor at four revolutions per minute. In normal operation, the polar axis revolves at standard time, once in 24 hours. To compensate for other time, the frequency of the inverter is altered. The battery is just a standard 12-volt auto battery, but I have divided it into two 6-volt units so I may charge it from the car generator. Then there are taps brought out at 6, 8, 10, and 12 volts to drive various equipment.

The inverter draws current from the 12-volt outlet. This is through a heavy rheostat so the inverter voltage may be

The equatorial mounting of W. C. Cheney's portable telescope is designed for maximum rigidity. The parts above the tripod, moved as a unit, weigh 43 pounds.



Details of the fork and saddle.

dropped to 10½. This gives a vernier adjustment on the frequency of the inverter and in turn on the motor speed. The inverter's normal frequency is determined by its vibrating reed contacts. A slight change in the output voltage makes a slight change in the reed frequency and a resultant change in motor speed. I have four vibrators for the inverter. It takes only a moment to change them. Each one I have accurately tuned for a definite frequency.

Due to the nearly perfect balance and ball bearings, there is almost no load on the motor and the battery drain is light. Before starting accuracy tests, I let the unit run for 10 minutes with the battery freshly and fully charged. This takes the peak voltage off of the battery. After proper adjustment, at the end of a four-hour run I could visually detect no variation in the driving rate, when timed with a very fine chronometer. Due to our usual bad weather I have been unable to run photographic tests to see if there are gear disturbances. However, a glass of water placed on the telescope tripod during regular operation shows no surface agitation.

The tube of the telescope has a flat plate bolted to it. This in turn is bolted to a saddle in the arms of which are two threaded holes. The saddle is placed between the forks, which are also bored. Then the two studs carrying the declination gear and the counterbalance weight are screwed through the fork and into the saddle. This construction and assembly is not as complicated as it sounds, and I use it because I have five other instruments that may be mounted on the saddle or between the forks.

The approximate weights of the parts are 43 pounds for the complete head, gearing, fork, tube, cradle, and polar axis; 29 pounds for the scope tripod alone; 12 pounds for the motor tripod mounting complete; battery 30 pounds, and inverter six pounds. These last two items cost $31.00 and $49.50, respectively, and the Telechron motor was $12.00. Aluminum alloy, all extruded, cost about $130.00, and the alloy steel $20.00. Material for many of the small parts came from my torch and burner shop.

When moving to location, the parts are separated as listed by weight. To save space and protect the parts, here in the shop, I keep the unit assembled. In less than 30 minutes I have taken it down and stowed it in the car, whereas setting up requires about an hour, including the tightening of all bolts so the instrument is one rigid unit.

The camera shown in the pictures is a Kine Exakta, and I have special mounts for other cameras, including a Cine Special, and two plate cameras. My photographic work will be confined to the sun and moon, and a reflex camera enables me to locate my subject quickly. I am now working on an ultra-ultra short-wave receiver to replace the telescope on the mounting, to study radiations from space. No setting circles are used with this equipment yet, but when I need to record observations accurately I will build them.

W. C. CHENEY
P. O. Box 3282
Seattle 14, Wash.

ED. NOTE: Mr. Cheney's solar-lunar camera was briefly described in Gleanings in September, 1950, page 278. The front lens is an Eastman Aero Ektar, 24 inches focal length, f/6. The rear lens is a war surplus eyepiece of 1¼-inch focal length, f/0.8, composed of six elements. All air surfaces of both lenses are anti-reflection coated.

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Visual Observing Programs for Amateurs — X

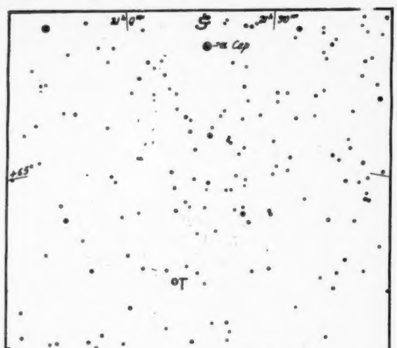
Variable Star Observing

THE previous articles of this series have described our observing tools and have outlined the type of work for which each is most suitable. Now we shall put them to work.

A variable star is a star which changes up and down in brightness over a period of hours, days, weeks, or months. To estimate its magnitude, we point our telescope at it and compare the brightness of the variable star with the brightnesses of surrounding comparison stars whose magnitudes are shown on our charts. If it appears intermediate in brightness between, say, a 9.6-magnitude star and a 10.1-magnitude star, we enter it on our daily log as being of magnitude 9.8 or 9.9 depending upon whether it seems nearer to 9.6 or 10.1.

The principle is simple, but it must be admitted that the whole process is encompassed by so many esoteric details that it is rather overpowering at first. This discussion of variable star observing will be devoted to clarifying the details.

If the heavens were conveniently studded with variables of naked-eye brilliance, it would be easy to start variable star observing by eye, but in practice we must turn at once to large binoculars or our telescopes. True, there are a few variable stars that can be seen with the naked eye, but mostly they are more suitable for special work by experienced observers than for the untrained eye of the beginner. My eye can just detect with some uncertainty a change of 0.1 magnitude or a 10 per cent change in a star's light. Most of us, therefore, will do well to spend the greater part of our observing time on stars which change a couple of magnitudes or more in brightness. This qualification eliminates most eclipsing variable stars such as Algol, Cepheids, and slightly irregular stars like Betelgeuse and Gamma Cassiopeiae. It leaves us with the long-period variable stars and the special stars which are the backbone of the observing program of the American Association of Variable Star Observers (AAVSO) and doubtless of other variable star groups and associations on other continents. A few of these stars reach naked-eye visibility at times, such as 021403 Mira, 184205 R Scuti, and 194632 Chi Cygni, but most of them even at maximum require binoculars at least and 3-inch to 12-inch telescopes in general.



The AAVSO finder chart for T Cephei, reduced to about three fifths its original size, shows stars to about 8th magnitude.

The numerous details which now confront us may be considered under six different headings. These are: 1. Charts and observing instructions. 2. Locating a variable star. 3. Estimating its brightness. 4. Organizing our observing program. 5. Reporting observations. 6. What is done with the observations that we report?

1. Charts and observing instructions. Some instructions and practice charts are included in the **Observer's Handbook** of the Royal Astronomical Society of Canada. The British Astronomical Association and the New Zealand Astronomical Society have variable star sections. However, those who wish to undertake a serious program of variable star observing and who live in the Western Hemisphere would do well to get in touch with the recorder of the AAVSO, at Harvard College Observatory, Cambridge 38, Mass. The AAVSO furnishes at cost to its members an instruction booklet, report forms, and star charts. If you have a friend nearby who is a reporting variable star observer, an evening spent with him may be helpful, but I regret to say that there are scarcely more than 100 such observers in North America, and in any case doing the work oneself is the only way to learn it.

2. Locating a variable star. If you have a telescope with circles in good adjustment, on a pier, these may be of minor assistance in locating a variable star. But even so, to identify the star definitely you must refer to a chart and pick out the star by its geometrical orientation with regard to its neighbors. Most of us do not have or need circles. The stars themselves act as reference points and lead us to whatever variable star we want to find.

Let us practice on the long-period variable star 210868 T Cephei. This star has a suitable magnitude range from about 6 to 10 and a period of 387 days, exhibits the interesting property of a still-stand on the way to maximum, and is located near enough to the north pole so as to be observable at some time of every night in the year in mid-northern latitudes. We need AAVSO "a," "b," and "d" charts of the field of T Cephei; a finder chart for T Cephei such as that reproduced here, or a detailed star atlas showing stars to the 8th, 9th, or even 10th magnitude; an AAVSO **Atlas** or equivalent showing stars to the 6th magnitude and the locations of many variable stars; and a 3-inch telescope or larger, with a finder of 8 or 10

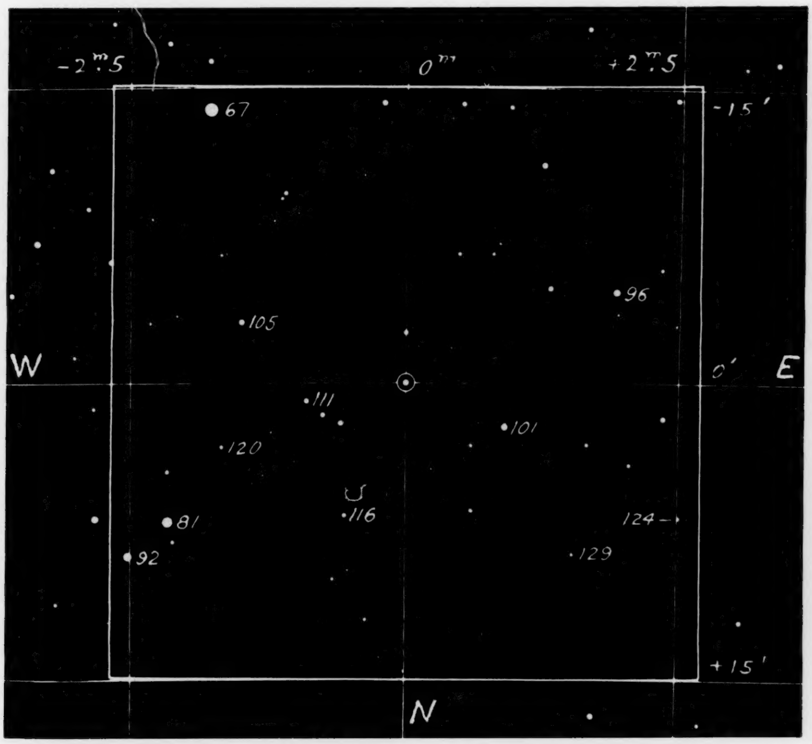
power and a 1¼-inch or 1½-inch objective lens. We also need a pocket flashlight small enough to be held in the teeth, and we take it and all our charts and atlases with us to the telescope.

The first four figures, 2108, in the designation of the star indicate that at epoch 1900.0 the star was at right ascension 21 hours 08 minutes, and the last two figures, 68, indicate that its declination was 68 degrees north. (If these two figures had been underlined, or the entire number had been in italics or in bold face, it would have indicated that the star was in south declination.) In spite of precession, the co-ordinates of T Cephei won't have changed much in 50 years, but in any case its location with regard to its neighbors will not have changed a hair's breadth since the chart was made.

The AAVSO **Atlas** shows us that T lies southwest of Beta Cephei. We look for Beta Cephei in the sky and point our finder at it. Then we refer either to the AAVSO finder chart or to some star atlas showing stars to the 8th, 9th, or 10th magnitude, and to the AAVSO "b" chart of the field of T Cephei (see back cover). We find that T Cephei lies near three other stars of tolerable brightness which form a right-angle triangle with sides approximately 24, 32, and 40 minutes of arc in length. As shown by our T Cephei "b" chart, these stars are of 67, 71, and 81 magnitude (actually 6.7, 7.1, and 8.1 magnitude, as the decimal points are omitted on the chart for fear they might be mistaken for stars). Thus, at least the two brighter stars will be visible in our finder and, of course, quite bright in our main telescope, though in the latter we may see at one time only two of the three stars forming the triangle because the asterism may be too large for us to see all of it at once.

If we can locate this triangle, we shall have no difficulty in finding T Cephei in the telescope, as we see that it lies near the shorter side of the triangle. By looking at our finder chart or our detailed atlas we note that there is a curved line of eight stars, of around the 8th magnitude, extending from Beta Cephei to the 67-magnitude star shown on the "b" chart. As we have already pointed the telescope at Beta Cephei, we use the finder or the main telescope with a low-power eyepiece of 20x or 30x, whichever is the most convenient instrument to look through, and follow our trail of stars to 67, located at the right angle of the triangle. Then we look through the main telescope.

But now we are puzzled. T Cephei is marked so plainly on its chart that we certainly expected to see our three triangle stars and T Cephei as well, or four bright stars in total, but we only see three stars. Can we have made a mistake? No — we check again starting from Beta Cephei and arrive again at our little triangular asterism. Then we suddenly remember that, since T is a variable star, it may not be bright, but may be faint. We put in a slightly higher-power eyepiece, say 40x. Sure enough, after careful scrutiny we see a faint star in the location where T ought to be. Can it be T? We notice a 101-magnitude (10.1) and a 105-magnitude (10.5) star on our T Cephei "d" chart (reproduced here), one lying on either side of where T ought to be. If we can see these in the sky, and if the



The central portion of the AAVSO "d" chart for T Cephei, reproduced to original scale, but with some additions from the margins of the original chart. The co-ordinates are centered on the star, and the heavy square is half a degree on its sides. The variable star is encircled, as also on the back-cover chart.

SKY-GAZERS EXCHANGE

star that we suspect is T lies in the right relation to them, then our identification is certain. We do see them in the sky and their relative positions are correct. We check again, comparing the sky against our T Cephei variable star chart, for this is our first variable star, and finally become convinced that we have cornered T.

This same general method can be used to locate any variable star, but it must not be supposed that this process is easy at first. The first variable I ever observed, 052404 S Orionis, took me an hour to locate. Now it would take me but a few seconds for I am familiar with its field. However, nowadays I can locate and observe a star totally new to me in about six minutes.

Certain difficulties will arise. Until we get used to our own instrument, we will not have any idea how bright stars will appear. For instance, we cannot tell from looking at our charts how bright the 67-magnitude star near T Cephei will appear in our finder or our main telescope. Will it look like Sirius to the naked eye, or more like Polaris? (Probably even fainter than the latter.)

We have no idea of the scale of size of asterisms in the sky. Are those three stars we see forming a triangle on the "b" chart of T Cephei close together when seen in the finder or far apart? (The answer probably is that they will seem about one quarter as big as the bowl of the Big Dipper does to our eye.)

When we move from the finder to the main telescope can we see all the asterism we are looking for, or half of it, or only one star of it, or on the other hand does it occupy only a small area in the field of view? (Probably we can only just take in the entire asterism in our field of view at 40x, and when we move the telescope so as to center it on T Cephei we will only see the two nearest members of the triangle.)

Only experience with our own instrument can give us a sense of judgment in these matters. Moreover the eye must be trained to see faint stars. S Orionis, the first variable star that I ever observed with my 6-inch refractor, was then of magnitude 10.2, and I found it difficult to see. I could see a 13.2-magnitude star now with greater ease.

In our next installment we shall continue this discussion, opening with a consideration of orientation problems.

DAVID W. ROSEBRUGH
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Waterbury 10, Conn.

VARIABLE STAR MAXIMA

January 1, S Sculptoris, 6.8, 001032; 3, W Andromedae, 7.5, 021143a; 6, T Centauri, 6.1, 133633; 9, R Carinae, 4.6, 092962; 16, U Ceti, 7.5, 022813; 20, T Aquarii, 7.9, 204405; 22, R Sagittarii, 7.2, 191019. February 2, R Normae, 7.2, 152849; 10, RR Scorpii, 6.0, 165030a.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

SATURN'S SATELLITES

SEVEN of Saturn's satellites may be viewed in a 6-inch reflecting telescope. This year the planes of the seven inner moons are nearly edge on, therefore no diagram need be shown: their orbits appear as straight lines in the equatorial plane of the planet.

Satellite	Synodic Period days	hours	Magnitude	Mean Distance
Mimas	0	22.6	12.1	27″
Enceladus	1	8.9	11.6	34″
Tethys	1	21.3	10.5	43″
Dione	2	17.7	10.7	55″
Rhea	4	12.5	10.0	76″
Titan	15	23.3	8.3	177″
Hyperion	21	7.6	13.0	214″
Iapetus	79	22.1	10.1-11.9	515″
Phoebe	523	15.6	14.5	1870″

For the first five satellites listed below the times given are for eastern elongation only, every eighth one for Mimas, Enceladus, and Tethys, and every fourth one for Dione and Rhea. For Titan and Iapetus the configurations around the orbit are given: **E**, eastern elongation; **I**, inferior conjunction; **W**, western elongation, and **S**, superior conjunction. The month is given, then the day and the hour in tenths, Universal time. For instance, for Titan the first event is an inferior conjunction with Saturn occurring on January 1st at $16^h.2$ UT. The brightness of Iapetus is variable; compare it with the other satellites.

Mimas. January: 0, 3.4; 7, 16.4; 15, 5.3; 22, 18.3; 30, 7.2. February: 6, 20.1; 14, 9.0.

Enceladus. January: 0, 14.8; 11, 13.8; 22, 12.8. February: 2, 11.9; 13, 10.9.

Tethys. January: 0, 1.1; 15, 3.6; 30, 6.0. February: 14, 8.4.

Dione. January: 1, 14.5; 12, 13.2; 23, 11.9. February: 3, 10.6; 14, 9.3.

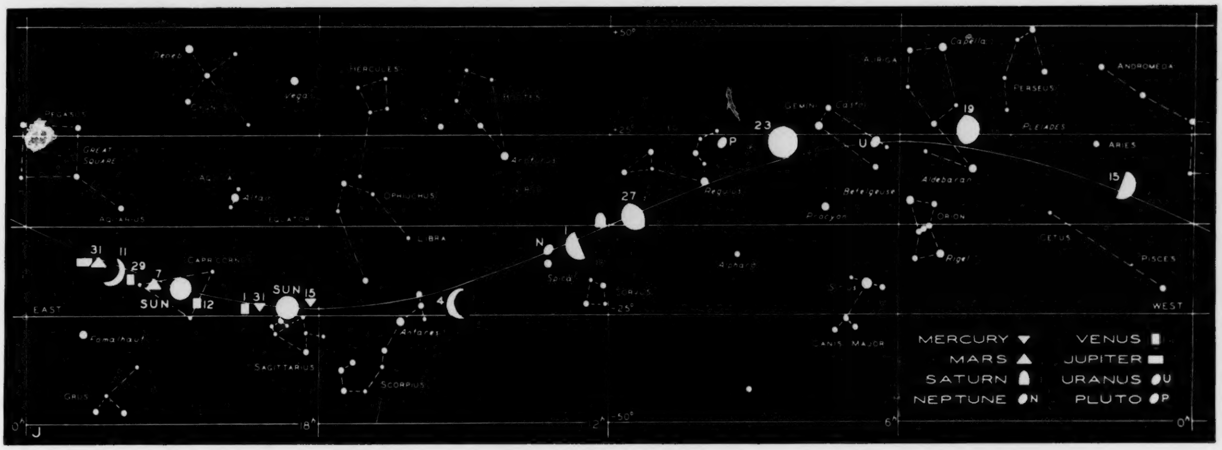
Rhea. January: 1, 8.3; 19, 10.0. February: 6, 11.5.

Titan. January: **I**, 1, 16.2; **W**, 5, 16.6; **S**, 9, 21.3; **E**, 13, 20.2; **I**, 17, 14.9; **W**, 21, 15.3; **S**, 25, 19.9; **E**, 29, 18.6. February: **I**, 2, 13.3; **W**, 6, 13.5; **S**, 10, 18.0.

Iapetus. January: **I**, 1, 15.6; **W**, 20, 18.0. February: **S**, 10, 3.0.

QUADRANTID METEORS

One of the better annual meteor showers, but little known and poorly observed in the United States, makes its appearance this month. The Quadrantids come to maximum on January 3rd, with a predicted rate of 40 meteors per hour under good circumstances. Rather favorable conditions, excepting weather, prevail with the moon past last quarter. The radiant is at 230°, +52°, in northern Bootes; the meteors are of medium speed. E. O.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown.

Mercury enters the morning sky on the opening day of 1951 as it passes inferior conjunction with the sun. In 22 days, Mercury recedes from the sun in the sky to a distance of 24° 31′, at greatest western elongation on January 23rd. At that time, the planet rises 1½ hours before sunrise and it is of zero magnitude. Mercury may be watched from about January 10th through the first week of February.

Venus, moving slowly eastward from the sun in the evening sky, sets about one hour after the sun; thus, it is observable only in the twilight, its magnitude —3. In a telescope the planetary disk is 10″ in diameter and nearly circular, 97 per cent illuminated. In early February, Venus is occulted for observers in the United States, as described elsewhere in this department.

Mars' setting time remains nearly constant at about 7:25 p.m. local time, as shown by the **Graphic Time Table of the Heavens** on page 66. It must be searched for carefully, as it is of the 2nd magnitude. It has a close conjunction with Jupiter on February 7th, about 19^h Universal time. Before then, it will seem to be squeezed between Venus and Jupiter.

Jupiter, setting four hours after the sun on January 1st, sets only 2½ hours after sunset on the 31st. The planet, located in Aquarius, slightly exceeds Sirius in brightness. On the evening of January 10-11, the three-day-old moon will be just west of Jupiter.

Saturn is the lone naked-eye planet visible in the midnight sky. This situation will not be altered for some months. Located roughly three fifths of the way along the ecliptic from Regulus in Leo to Spica in Virgo, Saturn moves slowly eastward until January 13th, when it is stationary at the beginning of its retrograde motion.

The ring system now shows its northern face, but only inclined 4°.2 to our line of sight. Its apparent dimensions are now 41″ major and 3″.1 minor axis, with the planetary disk of 16″.5 polar diameter on the 15th.

Uranus will be above the horizon all night, observable with slight optical aid. It is 6th magnitude, and is about two degrees northeast of Mu Geminorum, moving slowly westward.

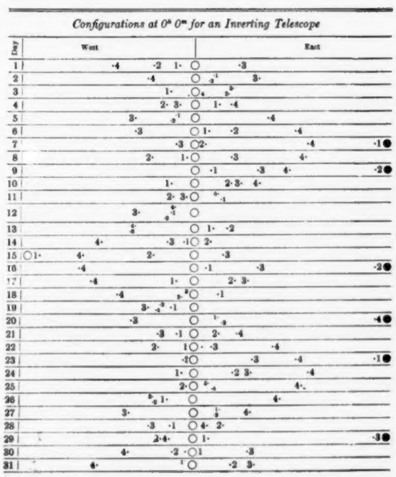
Neptune comes to western quadrature with the sun on January 10th, hence it may be found during the latter half of the night. Its position on the 15th is at right ascension $13^h\ 14^m.6$, declination —6° 8′, and it is of the 8th magnitude. E. O.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the American Ephemeris and Nautical Almanac.



PHASES OF THE MOON

Last quarter	January 1,	5:11
New moon	January 7,	20:10
First quarter	January 15,	0:23
Full moon	January 23,	4:47
Last quarter	January 30,	15:13
New Moon	February 6,	7:54

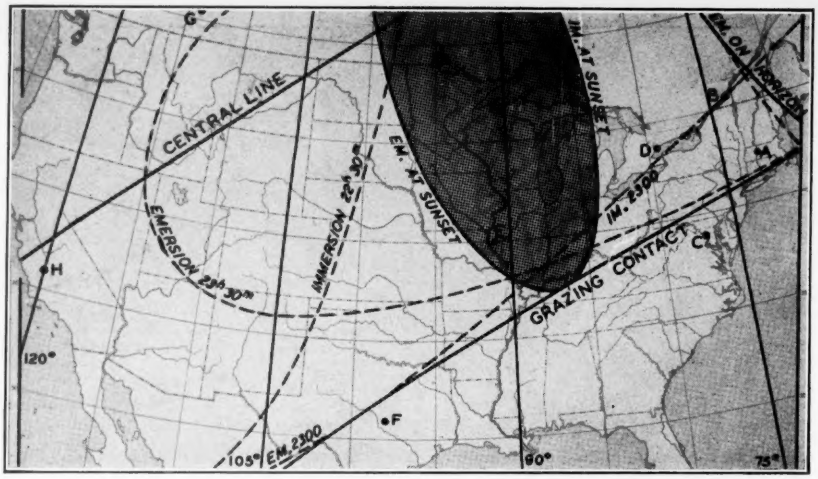
	January	Distance	Diameter
Perigee	6, 13^h	223,400 mi.	33′ 14″
Apogee	18, 14^h	252,000 mi.	29′ 28″

PREDICTIONS OF BRIGHT ASTEROID POSITIONS

No. 20	**Massalia**		Mag. 8.4	
	h	m	°	′
Jan. 14	10	02.6	+10	49
24	9	57.1	+11	16
Feb. 3	9	48.9	+11	58
13	9	39.4	+12	48
23	9	30.1	+13	38
Mar. 5	9	22.5	+14	20
No. 28	**Bellona**		Mag. 9.2	
	h	m	°	′
Jan. 24	10	01.1	+10	21
Feb. 3	9	54.7	+11	43
13	9	47.0	+13	14
23	9	39.2	+14	44
Mar. 5	9	32.4	+16	05
15	9	27.6	+17	10
No. 13	**Egeria**		Mag. 9.4	
	h	m	°	′
Jan. 14	10	04.0	+40	27
24	9	56.4	+41	57
Feb. 3	9	45.9	+43	07
13	9	33.9	+43	43
23	9	22.3	+43	42
Mar. 5	9	12.9	+43	05

The above are predicted positions in right ascension and declination for the epoch 1951.0, for 0^h Universal time. The magnitude is that expected at opposition. In each case the motion of the asteroid is retrograde. The two-page ephemeris of bright minor planets from which this data was taken is available to all amateur astronomers in exchange for a self-addressed stamped envelope. Address your request to the Cincinnati Observatory, Cincinnati 8, Ohio. The complete 1951 asteroid ephemeris volume is for sale to amateurs at $1.08 postpaid from the same observatory, which is the International Astronomical Union's Minor Planet Center.

February Venus Occultation



A BEAUTIFUL CONFIGURATION of moon and planets occurs on the evening of February 7-8, 1951, when our satellite occults Venus while Mars and Jupiter are near mutual conjunction four degrees above them. All will be easily in view within the field of a prism binocular, while the earthshine on the crescent moon (about 40 hours old) will further enhance the spectacle.

The occultation will be visible over most of the United States, but where this is not the case the conjunction will be exceedingly close. In general, the region where the planet will at no time be hidden is the southeastern part of the country.

Conditions are most favorable in the vicinity of the Great Lakes where all or part of the occultation takes place during twilight hours. In the West, the entire phenomenon occurs in daylight. On account of the great brilliancy of Venus, it should be visible to the naked eye even when the sun is above the horizon. However, the small elongation of the planet will make it harder to see at that time than at a later season, so that slight optical aid is recommended for observers in the West.

The accompanying map is similar to the ones of solar eclipses which are familiar to all. The line of grazing contact is the southern limit of visibility of the occultation, while the central line shows where the planet will pass behind the center of the moon's disk.

A solid loop that meets the line of grazing contact in Kentucky shows where Venus will appear on the lunar limb at sunset. At the point of tangency, "immersion" and "emersion" at sunset will take place simultaneously. Along the eastern arm it is immersion, but on the western it is emersion, that occurs with the sun on the horizon. Within the loop (shaded) immersion takes place in daylight, but emersion does not come until twilight has begun to fade.

Observers east of the loop are most favored because the entire occultation takes place after sunset. In most of Maine, the moon will set with Venus behind its disk. A solid line in the extreme Northeast shows where emersion occurs with the planet on the horizon. Predictions in the **American Ephemeris and Nautical Almanac** suggest that this line is west of station **A**, since for that point it is stated that emersion takes place below the horizon. Perhaps this is the result of neglect of the effect of atmospheric refraction. Taking this into account, the writer predicts that emersion at station **A** comes at 23:36 UT and that the planet will not set until 23:53 UT.

There is a narrow wedge-shaped zone in Maine, New Hampshire, and Quebec, where emersion takes place after evening twilight has ended. Other curves show where immersion or emersion occur at specified hours.

Data for the map were determined by a combination of trigonometric and graphical computation. The apparent positions of the moon at certain stations at three times, taken at half-hour intervals, were calculated according to the method outlined on pages 307-8 in the October, 1950, issue of **Sky and Telescope**. These were located at five-degree intervals along the four standard meridians of longitude: 75°, 90°, 105°, and 120° west. The times of immersion and emersion at these stations were then found from diagrams similar to Figs. 3 and 4 on page 308. Then a system of graphical interpolation and extrapolation was used to locate points on the various curves on the map. Finally, smooth curves were drawn through the points.

An added attraction on February 7th will be the proximity of Mars and Jupiter above Venus and the moon. The two will be within half a lunar diameter of each other, and will themselves be occulted by our satellite a few hours later. In fact, in certain regions, the two superior planets will be simultaneously hidden by the earth's satellite; this will be seen best in the Pacific Ocean. On the West Coast, the moon will stand nearly midway between Venus and Jupiter during late twilight.

A small telescope will reveal all four of Jupiter's bright satellites east of the planet in numerical order of their distance from it. In the East, the first satellite will be seen to reappear from eclipse. This comes at 23:39 UT which, by coincidence, is the time of emersion of Venus at the writer's local station in Rochester, N. Y. Shortly afterward, the first two moons will pass each other. Then at 2:11 on February 8th, observers in the West may see the second moon begin to transit Jupiter's disk.

An occultation of Venus is a marvelous sight in its own right, but to have it take place on the same evening as the occultation of two other planets is something of a rarity. The most recent occasion on which anything approaching this occurred came in December, 1933, when Venus and Saturn were both occulted on a single evening in the western Pacific.

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OCCULTATION PREDICTIONS

January 16-17 **Epsilon Arietis m** 4.6, 2:56.4 +21-08.7, 9, Im: **A** 23:47.3 —0.5 +4.0 11; **B** 0:01.8 ... ... 352; **C** 23:31.3 —0.6 +3.6 16. Em: **A** 0:44.8 —2.8 —1.9 290; **C** 0:36.6 —3.0 —1.0 282.

January 17-18 **17 Tauri** 3.8, 3:42.0 +23-57.7, 10, Im: **A** 20:33.2 —0.5 +1.8 69; **C** 20:25.2 —0.3 +1.7 68. Em: **A** 21:43.8 —0.8 +2.1 239; **C** 21:33.1 —0.6 +2.0 239.

January 17-18 **20 Tauri** 4.0, 3:42.9 +24-13.0, 10, Im: **A** 21:19.8 —0.2 +2.6 36; **C** 21:10.1 0.0 +2.5 36. Em: **A** 22:27.2 —1.7 +1.1 270; **C** 22:15.6 —1.6 +1.2 270.

January 17-18 **Eta Tauri, Alcyone** 3.0, 3:44.6 +23-57.3, 10, Im: **D** 22:10.4 ... ... 135; **E** 21:44.9 —1.3 +0.7 113. Em: **D** 22:35.2 ... ... 173; **E** 22:29.7 +0.5 +3.4 194.

January 20-21 **49 Aurigae** 5.0, 6:32.1 +28-03.7, 13, Im: **A** 2:33.8 —2.1 +2.5 56; **B** 2:40.8 —1.9 +3.8 41; **C** 2:17.2 —2.0 +1.7 69; **D** 2:24.4 —1.6 +3.2 48; **E** 1:57.8 —1.1 +2.7 54; **F** 1:31.6 —1.1 +1.6 76; **H** 1:43.8 ... ... 15. Em: **A** 3:42.7 —1.8 —2.7 317; **C** 3:41.3 —2.2 —1.6 300; **E** 3:08.4 —2.3 —1.2 305; **F** 2:54.5 —2.2 +0.5 276; **H** 2:08.1 ... ... 334.

February 7-8 **Venus** —3.3, 22:44 —9-36, 2, Im: **A** 23:13.4 ... ... 129; **B** 23:00.4 —1.0 —2.7 106; **D** 22:58.8 —1.3 —2.8 107; **E** 22:49.3 —2.0 —2.3 102; **G** 22:15.5 —0.8 +0.8 32; **H** 21:52.7 —1.8 +1.2 50; **I** 22:07.1 —0.6 +1.4 20. Em: **D** 23:40.7 +0.3 +2.1 184; **E** 23:36.1 +0.3 +2.4 183; **G** 23:29.2 —1.2 —0.6 251; **H** 23:19.6 —1.2 +1.0 222; **I** 23:16.8 —1.7 —0.6 262.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

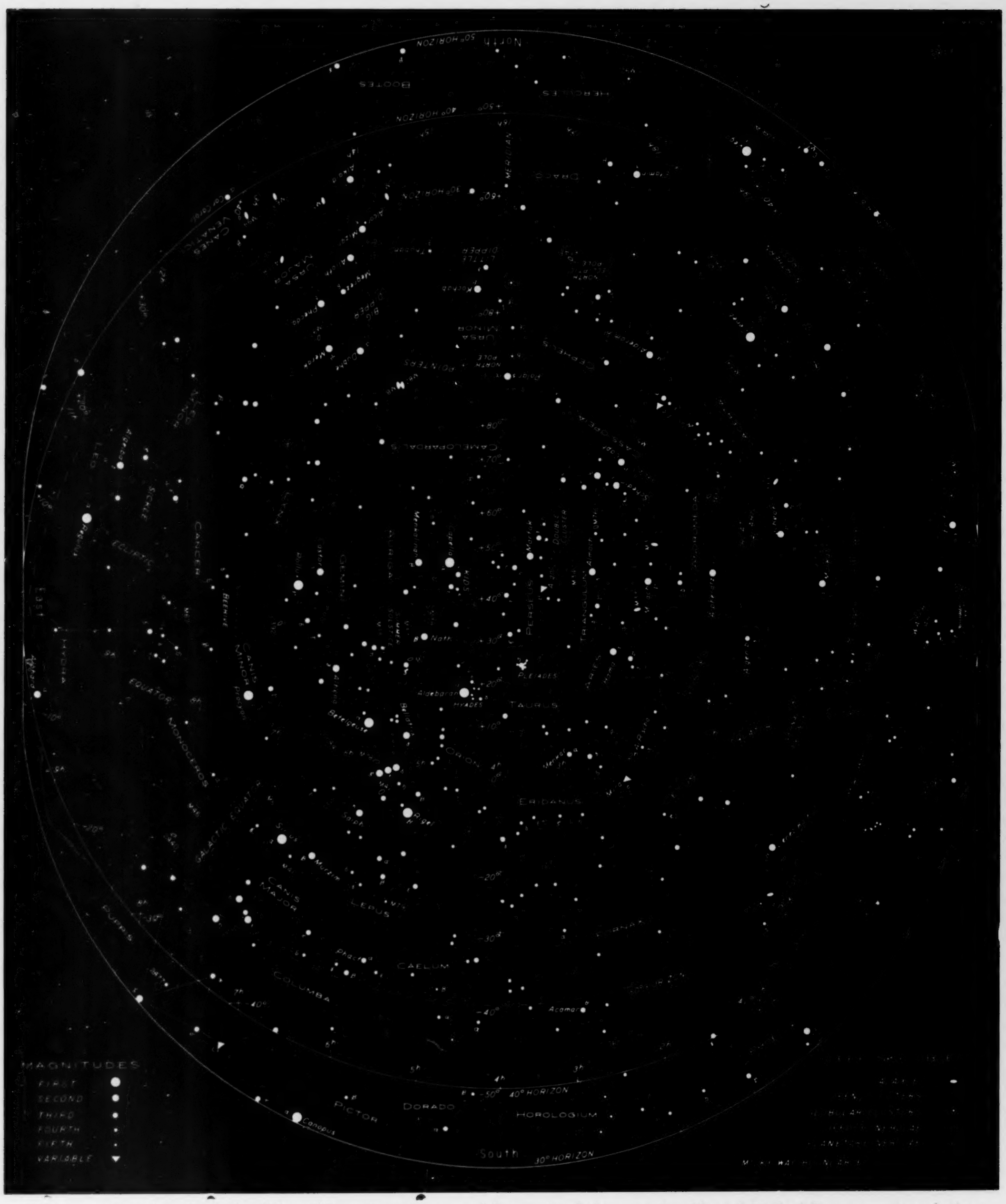
Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +31°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
I +123°.1, +49°.5	

Here and There with Amateurs

*Members receive *Sky and Telescope* as a privilege of membership. †Member organizations of the Astronomical League.

State	*City*	*Organization*	*Time*	*Meeting Place*	*Communicate With*
ALABAMA	Gadsden	Ala. A.A.	7:30, 1st Thu.	Ala. Power Audit.	Brent L. Harrell, 1176W or 55
ARIZONA	Phoenix	*Phoenix Obs. Ass'n.	8:00, 1st, 3rd Tue.	Phoenix College	Paul E. Griffin, 1708 S. 3rd St.
CALIFORNIA	Los Angeles	L.A.A.S.	7:45, 2nd Tue.	Griffith Obs.	H. L. Freeman, 853½ W. 57 St.
	Norwalk	*Excelsior Tel. Club	7:00, Thu.	Excelsior Union H.S.	Geo. F. Joyner, 12008 E. Sproul St.
	Oakland	*Eastbay A.S.	8:00, 1st Sat.	Chabot Obs.	Miss A. Roemer, 1556 Everett, Alameda
	Palo Alto	*Peninsula A.S.	7:30, 1st Fri.	Community Center	Mrs. D. Rossiter, 922 Roble Ave., Menlo Pk.
	Sacramento	*Sac. Val. A.S.	8:00, 1st Tue., bi-mon.	Sacramento College	Mrs. Helen Schopke, 3111 12th Ave. (17)
	San Diego	Ast. Soc. of S.D.	7:30, 1st Fri.	504 Electric Bldg.	W. T. Skilling, 3140 Sixth Ave.
	San Diego	A.T.M. Ast. Club	7:30, 2nd, 4th Mon.	3121 Hawthorn St.	G. A. Sharpe, 4477 Muir, Bayview 3757
COLORADO	Denver	*Am. Tel. Cl. of Den.	8:00, 2nd, 4th Mon.	Chamberlin Obs.	W. E. Johnson, 264 S. Gilpin St.
CONNECTICUT	Middletown	Centr. Conn. A.A.	8:00, 1st Tue.	Van Vleck Obs.	Walter Fellows, Middle Haddam
	New Haven	†A.S. of New Haven	8:00, 4th Sat.	320 York St.	Mrs. Helen Velardi, 437 Wash., N'th Haven
	Norwalk	Norwalk A.S.	8:00, Last Fri.	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-5947
	Stamford	Stam. Museum A.A.	8:00, 3rd Fri.	Stamford Museum	Thomas J. Page, 52 Frank St.
DIST. COL.	Washington	†Nat'l. Cap. Ast'mers	8:00, 1st Sat.	Comm. Dept. Audit.	Janet Perkins, 2141 Eye St. NW (7), RE 7676
FLORIDA	Daytona Beach	D. B. Stargazers	8:00, Alt. Mon.	105 N. Halifax Ave.	Wm. T. Thomas, 105 N. Halifax
	Jacksonville	*J.A.A.C.	8:00, 1st, 3rd Mon.	Private homes	E. L. Rowland, Jr., 442 St. James Bldg.
	Key West	†Key West A.C.	8:00, 1st Wed.	Private homes	W. M. Whitley, 1307 Div. St., 724-R
	Miami	South'n Cross A.S.	7:30, Every Fri.	M. B. Lib. Grounds	A. P. Smith, Jr., 426 S.W. 26 Rd.
GEORGIA	Atlanta	Atlanta Ast'mers	7:30, 2nd Fri.	Agnes Scott College	W. H. Close, 225 Forkner Dr., Decatur
ILLINOIS	Chicago	†*Burnham A.S.	8:00, 2nd Tue.	Chi. Acad. of Sci.	Wm. Callum, 1435 Winona St.
	Geneva	*Fox Valley A.S.	8:00, 1st Tue.	Geneva City Hall	Joseph Zoda, 501 S. 6th St., St. Charles
	Moline	†*Popular A.C.	7:30, Wed.	Sky Ridge Obs.	Carl H. Gamble, 3201 Coaltown Rd.
INDIANA	Indianapolis	†Indiana A.S.	2:15, 1st Sun.	Riley Library	Clark B. Hicks, 305 Ruckle St.
KANSAS	Topeka	*Topeka A.A.S.	7:30, 2nd Mon.	Topeka H.S.	Miss N. Utschen, 1607 Wayne Ave.
	Wichita	†*Wichita A.S.	8:00, 1st Wed.	....	Dollie Ratcliff, 801 Maple, 2-1822
KENTUCKY	Louisville	†L'ville A.S.	8:00, 1st Tue.	Univ. of Louisville	B. F. Kubaugh, 621 34th St.
	Owensboro	†*Owensboro A. C.	8:00, 3rd Sat.	Public Library	Hermann Batt, 1507 Hathaway St.
LOUISIANA	New Orleans	A.S. of N.O.	8:00, Last Wed.	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
MAINE	Portland	†A.S. of Maine	8:00, 2nd Fri.	Private homes	H. Harris, 27 Victory Ave., S. Portland
MASSACHUSETTS	Cambridge	†*Bond A.C.	8:15, 1st Thu.	Harvard Obs.	C. A. Federer, Jr., Harvard Observatory
	Cambridge	†*A.T.M.s of Boston	8:00, 2nd Thu.	Harvard Obs.	H. Smith, 26 Kingman St., Weymouth, 9-3438-R
	Springfield	†*S'field Stars	8:00, 2nd Wed.	Private homes	F. D. Korkosz, Mus. Nat. Hist., 2-4317
	Worcester	†*Aldrich A.S.	7:30, 1st, 3rd Tue.	Mus. Natural Hist.	Ralph A. Wright, 4 Mason St.
MICHIGAN	Ann Arbor	†Ann Arbor A.A.A.	7:30, 2nd Mon.	U. of Mich. Obs.	Stewart W. Taylor, 1106 Birk Ave.
	Battle Creek	†B. C. A.A. Club	8:00, 2nd Fri.	Kingman Museum	Mrs. W. V. Eichenlaub, 47 Everett St.
	Detroit	†*Detroit A.S.	3:00, 2nd Sun.	Wayne U., State Hall	E. R. Phelps, Wayne University
	Detroit	†*N.W. Detroit A.S.	8:00, 1st Tue.	Redford H. S.	John W. Broxholm, 21412 Pickford
	Kalamazoo	†Kalamazoo A.A.A.	8:00, Sat.	Private homes	Mrs. G. Negrevski, 2218 Amherst, 31482
	Lansing	†*Lansing A.A.	8:00, 1st, 3rd Wed.	Technical H. S.	Mrs. T. A. Louden, 940 Bensch St. (14)
	Pontiac	†*Pontiac A.A.A.	8:00, 3rd Sun.	Cranbrook Inst.	Mrs. M. Chircop, 147 Prospect St., 21455
MINNESOTA	Duluth	†*Darling A.C.	8:00, 1st, 3rd Fri.	Darling Obs.	Mrs. A. Lynch, 1911 Wisconsin, Superior, Wis.
	Minneapolis	M'polis A.C.	7:30, 1st, 3rd Wed.	Public Library	Jane Simmer, 2406 Clinton Ave. S.
	St. Paul	*St. Paul Tel. Club	7:30, 2nd, 4th Wed.	Macalester Coll.	Mrs. H. Wolcott, 1705 Scheffer Ave. (5)
MISSOURI	Fayette	†*Central Mo. A.A.	7:30, Last Sat.	Morrison Obs.	R. C. Maag, 611 Bluff St., Fulton
	Kansas City	†*A.A. & T.M.s	8:00, 4th Sat.	Private homes	Reginald Miller, Merriam, Kans.
	St. Louis	†St. Louis A.A.S.	8:00, 3rd or 4th Sat.	Inst. of Tech., St. L. U.	S. O'Byrne, 501 E. Pacific, Webster Groves 19
NEVADA	Reno	A.S. of Nev.	8:00, 4th Wed.	Univ. of Nevada	E. W. Harris, University of Nevada
NEW JERSEY	Caldwell	West Essex A.A.	8:00, 2nd Mon.	Caldwell Mun. Bldg.	D. C. Smith, 19 Francisco Ave., W. Caldwell
	Jersey City	†Revere Boys Club	7:15, Mon., Tue.	Gregory Mem. Obs.	Enos F. Jones, 339 Wayne St.
	Teaneck	†Bergen Co. A.S.	8:30, 2nd Wed.	Obs., 107 Cranford Pl.	J. M. Stofan, 332 Herrick
NEW YORK	Buffalo	†*A.T.M.s & Observers	7:30, 1st, 3rd Wed.	Mus. of Science	Dr. F. S. Jones, 83 Briarcliffe, Cheektowaga
	New York	*A.A.A.	8:00, 1st Wed.	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., EN 2-8500
	New York	†Junior A.C.	7:30, 4th Fri.	Amer. Mus. Nat. Hist.	J. Rothschild, Hayden Plan., EN 2-8500
	Rochester	†Rochester A.C.	8:00, Alt. Fri.	Rochester Museum	H. O. Woodard, 485 Hayward Ave. (9)
	Schenectady	†S'tady A.C.	8:00, 2nd Mon.	Schenectady Museum	C. E. Johnson, 102 State St.
	Troy	*Renss. Ap. Soc.	7:30, Alt. Tue.	Sage Lab., R.P.I.	S. J. Lukasik, 31 Belle Ave.
	Utica	†*Utica A.A.S.	7:30, 4th Tue.	Proctor Inst.	John Zimm, 239 Thieme Pl.
	Wantagh	Long Island A.S.	8:00, Sat.	Private homes	A. R. Luechinger, Seaford Ave., 1571
N. CAROLINA	Greensboro	†*Greensboro A.C.	8:00, 1st Thu.	Woman's Coll., U.N.C.	Mrs. Z. V. Conyers, 210 W. Fisher Ave.
	Raleigh	†Astronomical Soc.	....	N. C. State Coll.	C. F. Campen, Jr., Physics Dept.
	Winston-Salem	†*Forsyth A.S.	7:30, Last Fri.	Private homes	Kenneth Shepherd, 1339 W. 4th St.
OHIO	Akron	*A.C. of Akron	8:00, 2nd Fri.	Beth.-Luth. Church	Mrs. R. J. Couts, 878 Kennebec Ave. (5)
	Cincinnati	*Cin. A.A.	8:00, Various days	Cincinnati Obs.	Robert Berkmeier, 2432 Ohio Ave.
	Cincinnati	*Cin. A.S.	8:00, 3rd Wed.	5556 Raceview Ave.	John Dann, 3318 Felicity Dr. (11)
	Cleveland	†Cleveland A.S.	8:00, Fri.	Warner & Swasey Obs.	Mrs. A. Townhill, Warner & Swasey Obs.
	Columbus	*Columbus A.S.	8:00, Last Tue.	McMillin Obs.	J. A. Hynek, Ohio State Univ.
	Dayton	A.T.M.s of Dayton	Eve., 3rd Sat.	Private homes	F. E. Sutter, RR 7, Box 253A (9)
	Lorain-Elyria	*Black River A.S.	8:00, 2nd Mon.	Clearview School	Louis Rick, Box 231, Lorain
	Toledo	Toledo Ast. Club	...., 3rd Tue.	Univ. of Toledo Obs.	E. D. Edenburn, 4124 Commonwealth Ave.
	Warren	†Mahoning Val. A.S.	8:00, Thu.	Private homes	S. A. Hoynos, 1574 Sheridan, NE, 25034
	Youngstown	*Y'town A.C.	7:30, 1st Fri.	Homestead Pk. Pav'n.	F. W. Hartenstein, 905 Brentwood
OREGON	Portland	†*Portland A.S.	8:00, 1st Mon.	Planetarium	H. J. Carruthers, 427 S. E. 61 Ave.
	Portland	†A.T.M. & Observers	8:00, 2nd Tue.	Mus. of Sci. and Ind.	N. C. Smale, 831 N. Watts St.
PENNSYLVANIA	Beaver	†*Beaver Co. A.A.A.	8:00, 4th Tue.	Com'y Bldg., Tamaqui	Mrs. R. T. LuCaric, Box 463, Baden
	Philadelphia	†A.A. of F.I.	8:00, 3rd Fri.	Franklin Institute	Edwin F. Bailey, RIT 3050
	Philadelphia	*Rittenhouse A.S.	8:00, 2nd Fri.	Morgan Physics, U. Pa.	Sarah Lippincott, Sproul Obs., Swarthmore
	Pittsburgh	†*A.A.A. of P'burgh	8:00, 2nd Fri.	Buhl Planetarium	G. Winterhalter, 5-J Terrace, McKees Rocks
RHODE ISLAND	Providence	Skyscrapers, Inc.	8:00, Mon. or Wed.	Ladd Observatory	Ladd Obs., Brown U., Jackson 1-5680
S. CAROLINA	Columbia	North'n Cross A.S.	8:15, Every Mon.	Melton Observatory	Dr. L. V. Robinson, Univ. of S. C.
TENNESSEE	Chattanooga	*Barnard A.S.	8:00, 3rd Fri.	Jones Observatory	C. T. Jones, 302 James Bldg., 7-1936
	Nashville	*Barnard A.S.	7:30, 2nd Thu.	Vanderbilt Univ.	Miss J. Saffer, 446 Humphrey St. (10)
TEXAS	Dallas	†Texas A.S.	8:00, 4th Mon.	Various auditoriums	E. M. Brewer, 5218 Morningside, U6-3894
	Ft. Worth	†*Ft. Worth A.S.	8:00, 4th Fri.	Texas Christian U.	L. C. Eastland, 5501 Byers Ave. (7)
	Houston	Houston A.S.	7:30, Last Fri.	Mus. Nat. Hist. Annex	Mrs. J. Murray, 1007 W. Gray (6)
	Port Arthur	†*Port Arthur A.C.	...., 2nd Tue.	Private homes	G. van den Berg, Box 266, Groves
UTAH	Salt Lake City	†*A.S. of Utah	8:00, 2nd Fri.	City and County Bldg.	Junius J. Hayes, 1148 East 1 S.
VERMONT	Springfield	†Springfield T.M.s	6:00, 1st Sat.	Stellafane	John W. Lovely, 27 Pearl St., 535-W
VIRGINIA	Norfolk	†*A.A.S. of Norfolk	8:00, 2nd, 4th Thu.	Museum of Arts	A. Hustead, U.S. Weather Bureau, 21745
	Richmond	†Richmond A.S.	8:00, 1st Tue.	Builders Exchange	Miss L. Sievers, 4018 Clinton Ave. (27)
WASHINGTON	Spokane	*A.T.M.s of Spokane	....	....	D. K. Johnson, 301 S. 15th, Coeur d'Alene, Id.
	Tacoma	Tacoma A.A.	8:00, 1st Mon.	Coll. of Puget Sd.	Dorothy E. Nicholson, 2816 N. Union Ave.
	Yakima	†*Yak. Am. Ast'mers	8:00, 2nd Mon.	Cha. of Comm. Bldg.	Edward J. Newman, 324 W. Yakima Ave.
WISCONSIN	Beloit	Beloit A.T.M.s Club	...., Alt. Thu.	YMCA Bldg.	Kenneth W. Schultz, 959 Johnson St.
	Madison	†Madison A.S.	8:00, 2nd Wed.	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
	Milwaukee	†*Milw. A.S.	8:00, 2nd Mon.	Public Museum	E. A. Halbach, 2971 S. 52 St., W. Allis



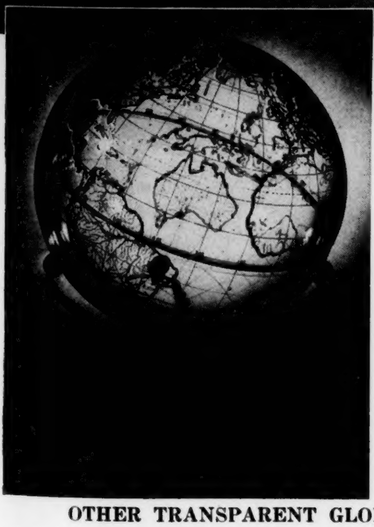
The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of January, respectively.

STARS FOR JANUARY

ERIDANUS, the River, occupies much of the central southern sky at this time of year. The star Beta, the source of the river, is known as Cursa, and is located just northwest of Rigel in Orion's foot. From there the river winds westward, and begins a huge meander with the star Gamma, known as Zaurak. The last star shown in the upper half of the meander is Pi, and then come nine stars in succession named Tau^1, Tau^2, and so forth. Tau^2 and Tau^7 are too faint to be shown on our chart, and Tau^9 is on the meridian directly south of Gamma. A visitor to the Boston Museum of Science planetarium recently suggested that this part of Eridanus resembles a harp.

Theta Eridani, named Acamar, was once called Achernar, for to the ancients this star was at the end of the river. Acamar is a good double star, its components of the 3rd and 4th magnitudes, about eight seconds of arc apart.

The 1st-magnitude star at the mouth of the river is Alpha Eridani, now called Achernar. It appeared on last month's chart. On January 15th, Achernar is near the meridian about six o'clock in the evening, visible to those living south of 32½° north latitude. It is the ninth brightest star in the sky, of magnitude 0.60.



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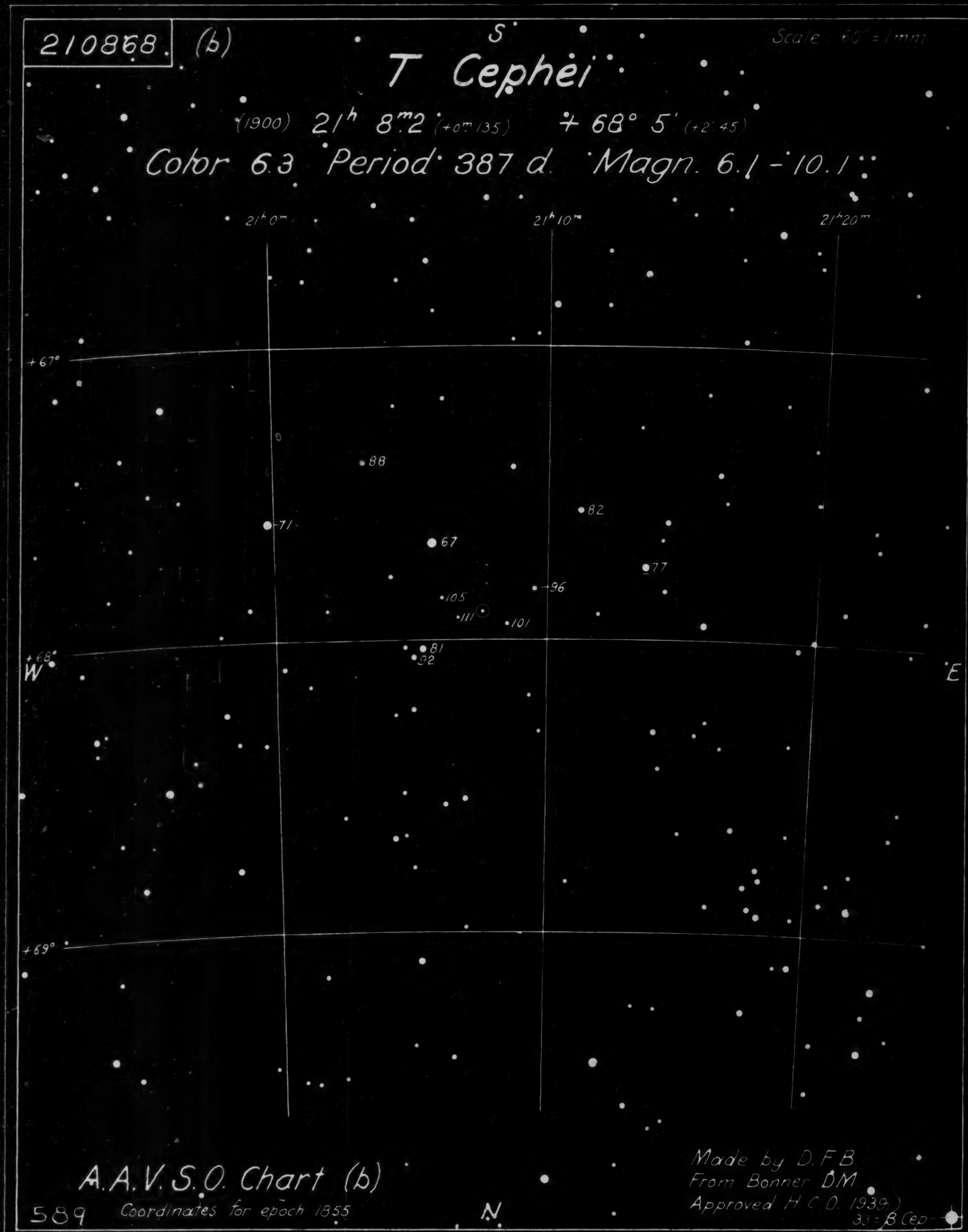
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A.A.V.S.O. Chart (b)
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Coordinates for epoch 1855
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